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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 5

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 3
Appendices H through M

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U.S. DEPARTMENT OF ENERGY
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APPENDIX H

COMPREHENSIVE RESPONSE ACTION RISK EVALUATION FOR OPERABLE UNIT 5

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LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Appropriate, Relevant, and Applicable Requirements
AWWT	Advanced Wastewater Treatment Facility
CDD	chlorinated dibenzo-p-dioxin
CDF	chlorinated dibenzofuran
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Constituents of Concern
CPC	Constitutents of Potential Concern
CRARE	Comprehensive Response Action - Risk Evaluation
CSF	cancer slope factor
d	day
DOE	U.S. Department of Energy
ECTran	Excel Crystal Ball Transport (model)
EPA	U.S. Environmental Protection Agency
FEMP	Fernald Environmental Management Project
FS	Feasibility Study
g	gram
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HQ	Hazard Quotient
IARC	International Agency for Research on Cancer
ILCR	Incremental Lifetime Cancer Risk
IRIS	Integrated Risk Information System
ISCUT2	Industrial Source Complex, Long-term, Version 2
kg	kilogram
L	Liter
LOAEL	lowest observed adverse effect level
LRA	Leading Remedial Alternatives
m^3	cubic meters
MCL	maximum concentration level
Mg	microgram
mg	milligram
mgd	million gallons per day
NCP	National Oil and Hazardous Pollutants Contingency Plan (National Contingency Plan)
NOAEL	no observed adverse effect level
ODAST	one-dimensional Analytical Solute Transport

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
pCi	pico curies
pcb	polychlorianted biphenyl
PRAs	Preferred Remedial Alternatives
PRGs	Preliminary Remedial Goals
PRLs	Preliminary Remediation Levels
RAECOM	Radon Attenuation and Cover Optimization with Moisture Effects
RAGS	Risk Assessment Guidance for Superfund
RAWPA	Risk Assessment Work Plan Addendum
RFC	Reference concentration
Rfd	Reference dose
RI	Remedial Investigation
RME	Reasonable Maximum exposure
ROD	Record of Decision
SOWC	Southwest Ohio Water Company
SSOP	Storm Sewer Outfall Ditch
STAR	Stability Array
SWCR	Site-Wide Characterization Report
SWF&IM	Surface Water Flwo and Infiltration Model
SWIFT	Sandia Waste Isolation Flow and Transport (model)
TEF	toxicity equivalency factors
TCDD	tetrachlorodibenzo-p-dioxin
UCL	Upper Confidence Limit
WAC	Waste Acceptance Criteria
y	year
yd^3	cubic yards

H.1.0 INTRODUCTION

The Comprehensive Response Action Risk Evaluation (CRARE) estimates the human-health risks associated with the Fernald Environmental Management Project (FEMP) site after all remedial actions have been completed. The CRARE calculates the site-related "incremental" risk to individuals from the combined sources of the FEMP's five operable units.

As defined in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Superfund program was designed to protect human health and the environment from current and potential threats posed by uncontrolled hazardous substance releases. CERCLA requires that the actions selected to remedy hazardous waste sites meet these criteria found in Risk Assessment Guidance for Superfund (RAGS). CERCLA further requires that when a remedial action results in residual contamination at a site, reviews must be planned and conducted to assure that human health and environment continue to be protected in the future. These objectives are defined in the Environmental Protection Agency's Risk Assessment Guidance for Superfund (EPA 1989a).

Specific guidance on implementation is provided in the National Oil and Hazardous Pollutants Contingency Plan (NCP) which sets the cleanup criteria for Superfund response actions. That is, the incremental risk to a receptor who is subject to the "reasonable maximum exposure" (RME) generally must not exceed an incremental lifetime cancer risk (ILCR) of 10^{-6} to 10^{-4} or a hazard index (HI) of 1. This CRARE was designed specifically to address these requirements.

In accordance with the 1991 Amended Consent Agreement between the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA), a CRARE will be submitted with the feasibility study (FS) report for each operable unit. This appendix is the CRARE for the Operable Unit 5 FS report.

The objective of the CRARE process is to provide a framework for developing the risk information necessary to assist decision-making at remedial sites. Specific objectives of the process are to:

- Provide a basis for determining residual concentrations of contaminants that can remain on site and whether these levels adequately protect public health
- Provide a consistent process for evaluating and documenting potential public health threats associated with the site

To achieve these objectives, the CRARE process was established to provide risk-related information from a site-wide perspective to decision makers and stakeholders who review the effectiveness of individual operable unit proposed remedial actions.

This CRARE first assessed the incremental risks that could reasonably be attributed to the remediated FEMP site by examining a range of hypothetical on-property and off-property receptors. This was done following the EPA risk assessment guidance and methodology in RAGS (EPA 1989) and using site-specific data to predict contaminant concentrations in site media following remedial action. The predicted risk levels for these receptors were further analyzed in light of FEMP operational history as well as the natural occurrence of the constituents of concern in the environment (i.e., background levels). The analysis provides three approaches to account for background concentrations of contaminants and their resultant risks. Coupled with an extensive uncertainty analysis, these comparisons provide valuable data to regulatory agencies and the public in the assessment of potential site-related health risks.

H.1.1 OVERVIEW OF CRARE PROCESS

The primary objective of the CRARE is to estimate, from a site-wide perspective, the incremental risk posed by the FEMP site after all operable unit remedial activities have been completed. The CRARE assesses predicted FEMP site conditions 1000 years after remediation. Incremental risks were assessed assuming implementation of the remedial alternatives proposed for each operable unit. This CRARE uses the preferred remedial alternatives (PRAs) for Operable Units 1, 2, 4, and 5 which were selected as a result of the comparative analysis of alternatives in their respective FS reports. For Operable Unit 3, whose FS is not yet complete, the leading remedial alternative (LRA) from the Site-Wide Characterization Report [(SWCR) DOE 1993a] was used. When the Operable Unit 3 FS is complete, the original LRA will be updated as necessary for consistency with proposed plans. As noted in the SWCR, "the LRA does not represent the pre-selection of the remedy and will be used solely for the purpose of estimating and evaluating the risks presented by the entire site."

Section 4.0 of this Operable Unit FS presents the initial screening of remedial alternatives evaluated for Operable Unit 5. Seven alternatives were retained after the initial screening (see Section 4.5 of this FS report) and were further analyzed against the nine criteria outlined in the NCP (see Section 5.2 of this FS report). This CRARE focuses on postremedial site conditions as determined by the Operable Unit 5 representative remedial alternative (defined in Section 5.0 of this FS report) in conjunction with the adopted site-wide remedy (see Section H.2.0).

The representative remedial alternative for Operable Unit 5 is Alternative 3A, Case 7, which defines the postremedial FEMP land use as an undeveloped park. Target receptors were selected which

represent the RME individuals for this scenario. These receptors include the on-property undeveloped park user, the off-property resident farm adult, and the off-property resident farm child. In addition, eight reference receptors were chosen as points of comparison under a hypothetical loss of institutional controls.

Based on the results of the Operable Unit 5 baseline risk assessment, preliminary remedial goals (PRGs) were developed for each of these target receptors. Appendix C of this FS report provides a detailed discussion of the PRG development process. These PRGs were further evaluated considering appropriate, relevant, and applicable requirements (ARARs) and cross-media impacts. Preliminary remediation levels (PRLs) were developed based on the modified PRGs and with consideration of media-specific background concentrations and analytical detection limits. These PRLs serve as the starting point for the CRARE risk projections.

EPA's comments on previous versions of the CRARE have been addressed in this submission. EPA comments were received on the following dates for the indicated operable unit draft CRAREs:

- Operable Unit 4, December 1993
- Operable Unit 4, February 1994
- Operable Unit 1 and 2, June 1994
- Operable Unit 2, October 1994

H.1.2 ORGANIZATION OF THE OPERABLE UNIT 5 CRARE

This CRARE is organized as follows for the step-wise progression of detailed information:

- H.1.0 Introduction:

  This section describes the CRARE and the CRARE process.

- H.2.0 Adopted Site-Wide Remedy and Postremedial Site Conditions:

  This section describes the adopted site-wide remedy and site conditions after all five operable unit remedial actions have been implemented. These conditions are the basis for this CRARE. Additionally, assumptions used to estimate site-wide risk based on the future postremedial conditions are presented.

- H.3.0 CRARE Fate and Transport Modeling:

  This section summarizes the methodology used to quantitatively predict estimates of contaminant concentrations due to migration of contaminants in the media at the FEMP. It includes discussions of: 1) the fate and transport models used, 2) the technical approach that determines the appropriate model for each potential exposure assessment, and 3) modeling results.

- H.4.0 Risk Characterization:

Risk characterization is the final step in determining risk and involves combining the information developed in the toxicity and exposure assessments. This information is integrated and presented as qualitative and quantitative estimates of incremental human- health risk.

- H.5.0 Uncertainty Analysis:

This section presents the analysis of the methods used in the CRARE to determine if risks have been under- or over-estimated.

- H.6.0 Summary and Analysis of Findings:

A summary of the incremental risk to each receptor is presented for the site-wide postremedial conditions. The risk results for the three target receptors are compared to the results for eight reference receptors postulated under a hypothetical loss of institutional controls.

- H.7.0 References:

Literature references cited are identified in this section.

- Attachments:

Attachments H.I and H.II present the approach, assumptions, and methods used in predicting the migration and concentrations of residual contaminants in water and air, respectively.

Attachment H.III details the calculations of exposure and intake of constituents of concern by receptor and by pathway.

Three sets of risk calculations are presented to provide decision-makers with necessary information in making sound decisions on true site-induced health risks. Each set of calculations represents a different assumption regarding background contamination. Attachment H.IV describes the principles and methods employed in the standard CRARE risk calculations (i.e., incremental risk). Complete calculation worksheets for each receptor are provided.

Attachment H.V. presents the complete worksheets for the same receptors using the Option A and Option B risk calculations. Option B does not take credit for naturally occurring levels of inorganic elements. Option A uses source terms that do not account for naturally occurring background levels of inorganic and radionuclides. The worksheets are set up to compare the three sets of risk calculations (i.e., CRARE approach, Option A, and Option B).

Attachment H.VI presents the results of the Monte Carlo analysis of exposure parameters and the distribution of environmental data and other supporting documents used in the CRARE uncertainty analysis.

H.2.0 ADOPTED SITE-WIDE REMEDY AND POSTREMEDIAL SITE CONDITIONS

This section provides a general description of the site-wide conditions that are assumed to exist after completion of the preferred, leading or representative remedial alternative for each operable unit. These final site-wide conditions provide the basis for development of source terms used in the modeling of exposure-point contaminant concentrations for this CRARE. Because Operable Unit 5 is the last operable unit to implement its remedial actions, the Operable Unit 5 PRLs will dictate final site-wide conditions. A site-wide remedy was therefore adopted to address the residual soils and waste considered in the Operable Unit 5 representative remedial alternative as well as the waste to be placed in the on-site disposal cell from other operable units. This CRARE evaluates the incremental risks to hypothetical receptors associated with the implementation of the adopted site-wide remedy. This section is intended to give a general overview of final site-wide conditions. For detailed information, refer to the individual RI or FS reports referenced in this section.

H.2.1 DESCRIPTION OF OPERABLE UNIT REMEDIAL ALTERNATIVES

Table H.2-1 and the following paragraphs describe the remedial actions proposed for each operable unit. The PRAs for Operable Units 1, 2, and 4 are summarized from their respective FS reports. The LRA for Operable Unit 3 is summarized from the SWCR. The representative remedial alternative for Operable Unit 5 is summarized from Section 5.0 of this FS.

H.2.1.1 Operable Unit 1 Preferred Remedial Alternative

The PRA for Operable Unit 1 includes the removal, pretreatment (crushing/shredding), and drying of waste; off-property disposal of waste pit materials, covers, liners, and excavated soils; and decommissioning and removal of the drying treatment unit and associated facilities. The contaminated debris will be disposed with Operable Unit 3 debris. The excavated areas will be backfilled with clean soil. The excavated volumes for disposition off site are presented in Table H.2-2.

Additional components of the PRA include construction of waste processing and loading facilities and equipment, and removal of water from open waste pits for treatment at the Operable Unit 5 Advanced Waste Water Treatment (AWWT) facility. The remedial actions for Operable Unit 1 are presented in the Proposed Plan for Remedial Actions (DOE 1994h).

H.2.1.2 Operable Unit 2 Preferred Remedial Alternative

The PRA for Operable Unit 2 as presented in the Operable Unit 2 Proposed Plan for Remedial Actions (DOE 1994i) includes excavation of all soils with constituent of concern (COCs) above the PRLs developed in the Operable Unit 2 FS, material processing for size reduction and moisture

TABLE H.2-1

OPERABLE UNIT REMEDIAL ACTIONS

Operable Unit	Key Activities
1-Waste Pits	Excavation of pit contents, caps, berms, and lining sustem Excavation of heavily contaminated soil underlying pits Drying of excavated soil and waste, as required Shipment of excavated material by rail to off-site disposal facility
2-Other Waste Units	Excavation of waste materials and adjacent contaminated soil Shipment to off-site disposal facility of material not meeting WAC of on-site disposal cell Placement of excavated material meeting WAC in central, on-site disposal cell
3-Production Facilities and Inventories	Off-site shipment of remaining waste and production inventories (including thorium) and decontamination residues Decontamination and demolition of all structures and facilities Recycling/reuse of generated debris and equipment to maximum extent practical Off-site disposal of rubble and debris not meeting WAS of on-site disposal cell Disposal in on-site cell of rubble and debris meeting WAC
4-Silos 1-4	Removal and verification of waste inventories Off-site disposal of vitrified waste Excavation of contaminated soil and placement of soil attaining the WAC on-site disposal cell Decontamination and demolition of silo structures and support facilities Placement of rubble and debris in on-site disposal cell
5-Environmental Media	Excavation of soils, sediment, and perched groundwater zones On-site disposal of soil, sediment, and waste sludge meeting WAC Off-site disposal of waste exceeding WAC Treatment of GMA/Perched groundwater and process wastewater at AWWT
All Operable Units	Long-term environmental monitoring program for FEMP Continued maintenance and surveillance of on-site disposal cell Performance reviews of site conditions by EPA every 5 years Continued federal ownership of on-site disposal cell are Restrictions placed in FEMP property deed pertaining to future uses of site

TABLE H.2-2

OPERABLE UNITS 1 THROUGH 5 MATERIAL DISPOSITION FOR THE ADOPTED SITE-WIDE REMEDY[a]

Operable Unit	Excavated Volumes (cu yd)	Disposition
1	6.28×10^5	Off-site disposal
2	3.60×10^3	Off-site disposal
	3.45×10^5	On-site disposal cell
3	1.58×10^5	On-site disposal cell
	4.32×10^4	Off-site disposal
4	1.40×10^4	Off-site disposal
	3.00×10^3	On-site disposal cell
5[b]	2.50×10^4	Off-site disposal
	1.75×10^6	On-site disposal cell
Adopted Site-Wide Remedy	2.30×10^6[c]	On-site disposal cell

[a] Remedial actions for Operable Units 1, 2, 4, and 5 are from their draft or draft final FS reports or proposed plans. The remedial action for Operable Unit 3 is from the SWCR.
[b] Volumes estimated for Operable Unit 5 account for residual soils and waste remaining after Operable Units 1 through 4 have been remediated. It does not include the wastes designated by other operable units for on-site disposal.
[c] Summation of volumes identified for on-site disposal from Operable Units 1 through 5.

control (if required), on-site disposal in an engineered disposal cell, and off-site disposal of a small fraction of the excavated material that exceeds the Waste Acceptance Criteria (WAC) of the on-site disposal facility. Free-standing water in the Lime Sludge Ponds will be removed and treated at the FEMP AWWT prior to its discharge to the Great Miami River. In the South Field area, excavation of contaminated material above the Operable Unit 2 PRLs will prevent significant amounts of contaminants from the source material from entering the Great Miami Aquifer via the sand lenses in the glacial till.

Non-soil material (e.g., concrete, drums, steel, pallets, etc.) from all subunits will be segregated, hauled to the staging and material preparation area, processed for size reduction, and placed in the on-site disposal cell. The contaminated material from the subunits will be excavated, transported, and placed in the on-site disposal cell in a manner that provides a single, stable source term. To improve the handling and compaction characteristics of the waste material, lime sludge will be mixed with

other waste material as necessary. The volumes estimated for disposal in the on-site disposal cell and at an off-site disposal facility are presented in Table H.2-2.

After excavation of apparent waste materials by Operable Unit 2, residual contaminated soil and waste materials will be evaluated using the area- and COC-specific PRLs developed for the Operable Unit 5 representative remedial alternative. If soils and waste are found to be present above PRLs, additional excavations would be completed to attain Operable Unit 5 PRLs in the Operable Unit 2 area. After additional excavation, the areas will be regraded, backfilled with soil as necessary, and vegetated.

H.2.1.3 Operable Unit 3 Leading Remedial Alternative

For the Operable Unit 3 LRA, buildings will be decontaminated and demolished. Contaminated material will be removed, treated and/or decontaminated, and temporarily placed in storage prior to final disposition. After Operable Unit 3 remedial actions are complete, soil placed in piles and containers as well as residual soil and perched water will be deferred to Operable Unit 5 for disposal. Decontamination and treatment residue will require further treatment and disposal. It is estimated that 2.21×10^5 cubic yards of contaminated material will be disposed on property while clean material will be free-released for reuse or recycling. The LRA for Operable Unit 3 is defined in the SWCR (DOE 1993a).

H.2.1.4 Operable Unit 4 Preferred Remedial Alternative

The PRA for Operable Unit 4 includes removing the waste stored in Silos 1, 2, and 3, stabilizing it by vitrification, and transporting it to an off-site disposal facility. Silos 1, 2, 3, and 4 will be decontaminated to the extent practical and demolished. Contaminated construction material from the silos and decant tank will be removed and temporarily stored on site for eventual treatment and disposal with Operable Unit 3 debris. Residual soils from Operable Unit 4 will be re-evaluated as part of the Operable Unit 5 representative remedial alternative to determine whether they are above or below the PRLs established for Operable Unit 5. Residual soils above the PRLs will be included in the Operable Unit 5 source term and volume estimations. The excavated volumes for disposal at an off-site disposal facility and in the on-site disposal cell are presented in Table H.2-2. These actions are presented in detail in the Proposed Plan for Remedial Actions at Operable Unit 4 (DOE 1994e).

H.2.1.5 Operable Unit 5 Representative Remedial Alternative

Operable Unit 5 consists of the environmental media (soil, sediment, and water) that remain on site after completion of the remedial alternatives for Operable Units 1 through 4. For Operable Unit 5, target receptor PRLs and disposal cell WAC were developed for each COC to comply with appropriate risk or environmental criteria. For the purposes of this CRARE, all soil not meeting the WAC is assumed to be sent off site for disposal.

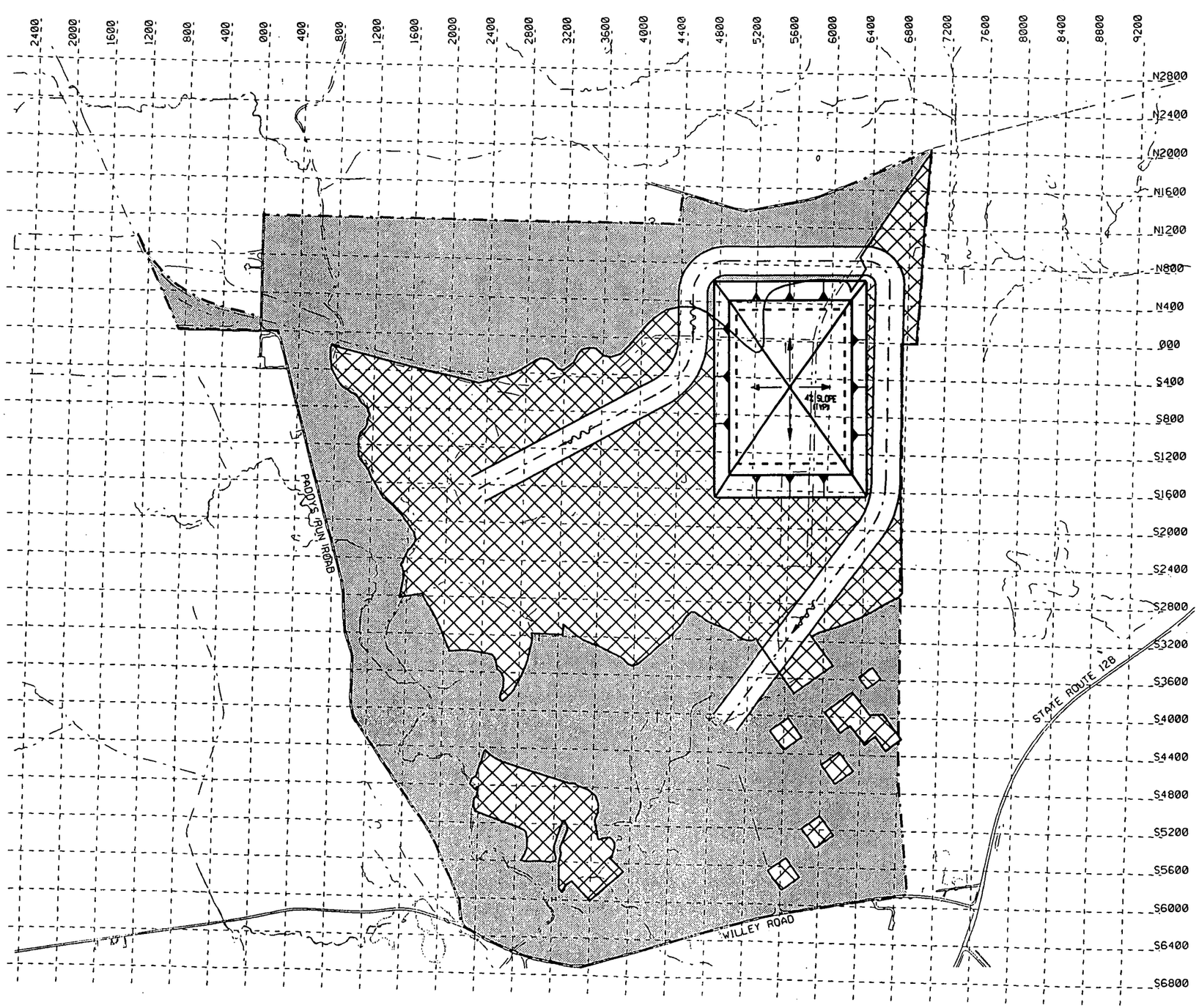
The representative remedial alternative for Operable Unit 5 includes excavation and on-site disposal of soils, sediment, and perched groundwater zones which have contaminant levels exceeding the target receptor PRLs under the undeveloped park land use scenario. All soils and sediment placed in the disposal cell must meet the WAC; any that exceed the WAC will be shipped off site. Groundwater from the Great Miami Aquifer, recovered perched groundwater, and process wastewater will be treated at the AWWT and discharged to the Great Miami River. Waste sludge generated by the water treatment will be dried, stabilized, and placed in the disposal cell or shipped off site. Table H.2-2 presents the volumes generated for disposal as a result of the Operable Unit 5 representative remedial alternative.

H.2.2 ADOPTED SITE-WIDE REMEDY AND POSTREMEDIAL SITE CONDITIONS

Since the implementation of remedial actions for Operable Unit 5 is assumed to occur after remedial actions for Operable Units 1 through 4, the PRLs and WAC for Operable Unit 5 will determine final site-wide conditions. The representative remedial alternative for Operable Unit 5 was developed based on a proposed land use as an undeveloped park. The PRLs for Operable Unit 5 were developed to protect target receptors relevant to an undeveloped park: the undeveloped-park user and off-property resident farmers. These PRLs were used to determine excavation areas and volumes for Operable Unit 5. The WAC are used to determine the type and volume of waste to be placed in the on-site disposal cell.

For this CRARE, the site-wide remedy was adopted to evaluate the consolidation of waste in an engineered on-site disposal cell. The volume estimated for disposal under this adopted site-wide remedy is 2.34×10^6 cubic yards (see Table H.2-2).

The postremedial site will include a single on-site disposal cell which contains consolidated contaminated soil, sediment, and debris designated for on-site disposal by Operable Units 1 through 5. Figure H.2-1 shows the postremedial site. Ownership of the disposal cell area, with restricted access, will be maintained by the federal government. The remaining area of the FEMP released for undeveloped park use will contain institutional controls (e.g., deed restrictions) to preclude development of the property.



LEGEND

- RESIDUAL CONTAMINATION AREA
- FEMP DISPOSAL CELL (AREA=2,250,000 SQ FT)
- REMEDIATED AREA ASSUMED AT BACKGROUND
- STORMWATER CONTROL CHANNEL

NOTE:
GRID SPACING = 400 FEET

500 0 600 1200 1800
SCALE IN FEET

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FIGURE H.2-1. SITE-WIDE REMEDY CONCEPTUAL DRAWING

H.2.3 DETERMINATION OF CONSTITUENTS OF CONCERN

The COCs evaluated in this CRARE were determined using a three step process: 1) screening the constituents of potential concern (CPCs) from the Operable Unit 5 RI report, 2) evaluating cross-media impacts from Operable Units 1 through 4 COCs not included on the Operable Unit 5 list of COCs, and 3) determining the COCs which contribute 95 percent or greater to the total risk.

The first step to this process was to take the CPCs identified in the Operable Unit 5 RI baseline risk assessment and screen them against an ILCR of 10^{-7} and HI of 0.1. Those CPCs which posed a risk or hazard greater than the specified screening levels were retained for further comparison against results from Step 2. Table H.2-3 presents the list of compounds determined to pose risk and hazard greater than 10^{-7} or 0.1, respectively.

Because the PRLs and WAC established for Operable Unit 5 will dictate final site-wide conditions (see Section H.2.2), it is possible that contaminants from Operable Units 1 through 4 may be present above the Operable Unit 5 PRLs and WAC. To ensure that COCs from other operable units were not disregarded, Step 2 was conducted as a confirmation procedure. This step involved a cross-reference of the compounds retained in Step 1 and those COCs from Operable Units 1 through 4 that were not considered for Operable Unit 5 and that may impact groundwater quality via cross-media mechanisms. Specifically, the COCs identified in the FS reports for Operable Units 1, 2, and 4, and the potential COCs identified for Operable Unit 3 from the SWCR that were not considered on the Operable Unit 5 COC list were evaluated using fate and transport modeling to determine cross-media impacts (e.g., soil to groundwater). Table H.2-4 presents the Operable Units 1 through 4 COCs evaluated for potential cross-media impacts. As a result of this modeling effort, no additional COCs from Operable Units 1 through 4 were found to pose cross-media impacts. Appendix F of this FS presents a detailed discussion of the modeling conducted to evaluate cross-media impacts. Because the fate and transport modeling for cross-media impacts did not result in additional COCs, the list of compounds retained from Step 1 and presented in Table H.2-3 properly represents the COCs for the Operable Unit 5 FS and was named as the comprehensive list of COCs.

The third step of this CRARE COC determination process was to identify compounds, presented in Table H.2-3, that collectively pose more than 95 percent of the total risk under the baseline condition. This was done by producing tables using RI risk data to illustrate percent contribution to total risk from each COC to each receptor via specific pathways, and identifying those COCs with risks equal to or greater than 95 percent of the total risk. Table H.2-5 presents the list of COCs quantitatively assessed in this CRARE.

TABLE H.2-3
OPERABLE UNIT 5 CONSTITUENTS
WITH ILCR > 10^{-7} OR HI > 0.1

Compound	
Chemical	
Alpha-chlordane	4-Methylphenol
Antimony	Molybdenum
Aroclor-1254	Nickel
Aroclor-1260	Nitrate
Arsenic	4-Nitrophenol
Barium	N-Nitrosodiphenylamine
Benzene	Octachlorodibenzo-p-dioxin
Benzo(a)anthracene	Octachlorodibenzofuran
Benzo(a)pyrene	Pentachlorophenol
Benzo(b)fluoranthene	Selenium
Benzo(k)fluoranthene	Silver
Beryllium	Tetrachloroethene
Bis(2-chloroisopropyl)ether	Thallium
Bis(2-ethylhexyl)phthalate	Thorium
Boron	1,1,2-Trichloroethane
Bromodichloromethane	1,1,1-Trichloroethane
Bromomethane	Trichloroethene
2-Butanone	Uranium
Cadmium	Vanadium
Carbazole	Vinyl chloride
Carbon disulfide	Zinc
Chloroform	
Chromium	**Radionuclide**
Chrysene	Cs-137
Copper	Np-237
Cyanide	Pb-210
Dibenzo(a,h)anthracene	Pu-238
3,3-Dichlorobenzidine	Pu-239
1,1-Dichloroethane	Pu-240
1,2-Dichloroethane	Ra-226
1,1-Dichloroethene	Ra-228
Dieldrin	Rn-222[a]
Di-n-butyl phthalate	Ru-106
Fluoride	Sr-90
Heptachlorodibenzo-p-dioxin	Tc-99
Heptachlorodibenzofuran	Th-228
Indeno(1,2,3-cd)pyrene	Th-230
Lead	Th-232
Magnesium	U-234
Manganese	U-235
Mercury	U-236
Methylene chloride	U-238

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

TABLE H.2-4

CROSS-MEDIA MODELING FOR CONSTITUENTS OF CONCERN IDENTIFIED FOR OPERABLE UNITS 1 THROUGH 4[a]

Compound	OU1	OU2	OU3	OU4
Chemical				
Acenaphthalene		X	X	X
Acetone			X	X
Anthracene			X	X
Aroclor-1221			X	
Aroclor-1248	X		X	
Benzoic acid			X	X
Benzo(g,h,i)perylene		X	X	X
Beta-BHC			X	
Butylbenzyl phthalate			X	
Carbon tetrachloride			X	
4-Chloro-3-methylphenol			X	
Chlorobenzene			X	
Chloroethane			X	
Cobalt		X	X	
4,4-DDE		X		
1,1-Dichloroethylene			X	
1,2-Dichloroethylene			X	
Diethyl phthalate			X	
Di-n-octyl phthalate			X	
Endrin		X		
Ethylbenzene			X	
Ethylether			X	
Fluoranthene		X	X	X
Fluorene			X	
2-Hexanone		X		
Methanol			X	
2-Methylnaphthalene		X	X	
4-Methyl-2-pentanone			X	
Naphthalene			X	
N-Nitroso-di-n-propylamine			X	
Phenanthrene		X	X	X
Phenol			X	X
Pyrene		X	X	X
Styrene			X	
1,1,2,2-Tetrachloroethane			X	
Tetrachlorodibenzo-p-dioxin	X	X		
Tetrachlorodibenzofuran		X	X	
Tetrachloroethane			X	
Toluene		X	X	X
Tributyl phosphate			X	
Xylenes (Total)			X	
Radionuclide				
Pa-231				X

[a]Potential COCs for Operable Unit 3 were taken from the SWCR. Final COCs for Operable Units 1, 2, and 4 were taken from their respective FS reports.

TABLE H.2-5

CONSTITUENTS OF CONCERN FOR OPERABLE UNIT 5 CRARE[a]

Radionuclides	Inorganics	Organics
Ra-226 + 4d	Antimony	Aroclor-1254
Sr-90 + 1d	Arsenic	Aroclor-1260
Tc-99	Beryllium	Benzo(a)Pyrene[b]
Th-230	Cadmium	1,2-Dichloroethane
Th-232 + 10d	Magnesium	2,3,7,8-Tetrachlorodibenzo-p-dioxin[b]
U-235/236 + d	Manganese	Trichloroethene
U-238 + 2d	Mercury	
	Silver	
	Uranium-total	

[a]This table includes those COCs which contribute 95 percent or more of the total ILCR and HI.
[b]Concentrations of these compounds were determined from TEF analysis of other carcinogenic PAHs, dioxins, and furans identified on site.
SOURCE: Derived from the Operable Unit 5 RI report (DOE 1994f).

The selection of CRARE COCs was accomplished using environmental data from Operable Units 1, 2, 4, and 5, which have been through the quality control procedures established for the FEMP site, and data from the SWCR for Operable Unit 3. At the presentation of this report, Operable Unit 3 had not completed its RI/FS. It is possible that the COCs identified by Operable Unit 3 during the RI phase may differ from those presented in the SWCR. If additional COCs are determined by the Operable Unit 3 RI studies, they will be evaluated and possibly incorporated into the list presented in Table H.2-5 for further evaluation of potential site-wide impacts in the future.

H.2.4 ASSUMPTIONS USED IN THE CRARE

The intent of the CRARE is to estimate, from a site-wide perspective, the risk associated with the FEMP site up to 1000 years after all remediation efforts are complete. Because it is difficult to predict future conditions, assumptions were necessary to estimate future site-wide risks. The predicted outstanding features of the postremedial FEMP form the basis for these assumptions.

Postremedial site conditions will include an on-site disposal cell and residual soils within the excavated area. The disposal cell is assumed to be located in the northeast portion of the site. The contaminated materials slated for on-property disposal from all operable units (as described in Section H.2.3) are assumed to be placed in this disposal cell. Contaminated materials which exceed the Operable Unit 5 WAC for the disposal cell will be sent to an off-site disposal facility. Residual soils within the excavation area are also associated with all operable units.

Sources of residual contamination used for the CRARE approximate contaminants remaining after all five operable units have been remediated. Sources evaluated for groundwater contamination include the disposal cell, residual soil, and contaminants that will remain in the groundwater system after groundwater and perched groundwater remediation are complete. Remediation efforts within the remedial footprint are assumed adequate to prevent further groundwater contamination. Air modeling and direct contact pathways for surface soil assume that the residual soil is at current contaminant levels and that soil within the remediation footprint is at background levels. Direct radiation sources evaluated include the disposal cell and the residual soil. These sources are described in detail in Section H.3.0.

The COCs driving 95 percent or more of the total risk to all receptors evaluated in the baseline risk assessment were incorporated into a list of "major risk drivers." This list is used to establish a "risk range" that even in the worst case demonstrates compliance. Further quantitative analysis of the residual concentrations indicates a risk level within acceptable limits of the established target risk goal for the remedy.

H.3.0 CRARE FATE AND TRANSPORT MODELING

Fate and transport modeling was used to predict the movement of COCs through various environmental media to receptor locations. This section presents the approach, procedures, and results of the modeling for the adopted site-wide remedy. Appendix F presents the approach and results of the contaminant fate and transport modeling performed to support the evaluation of Operable Unit 5 remedial alternatives.

H.3.1 OBJECTIVES

The purpose of contaminant fate and transport modeling is to predict future exposures, under given remedial scenarios, to future on- and off-property receptors. During the CRARE process, fate and transport models are applied to predict COC migration from residual source areas to potential human receptors through environmental media over a 1000-year period after the adopted site-wide remedy is implemented.

This CRARE evaluates all of the environmental media (i.e., soil, sediment, air, surface water, and groundwater) and residual COC sources associated with postremedial site conditions for each of the five operable units at the FEMP. To develop a conceptual model of future COC migration, the general future conditions of the FEMP property and its environmental media must be established. The predicted conditions of the property are based on the anticipated remedial actions of the five operable units and include the following general assumptions:

- Air in the vicinity of the FEMP comprise the air media
- Surface soil and the underlying glacial deposits comprise the soil media
- The Great Miami River, Paddys Run, and the Storm Sewer Outfall Ditch (SSOD) comprise the surface water media
- Sediments within the surface water bodies comprise the sediment media, which also include materials carried in storm water runoff or plant effluent discharge to surface waters or drainage ditches
- The Great Miami Aquifer and perched groundwater zone in the glacial overburden are both part of the groundwater media

Fate and transport models were selected based on their appropriateness for a specific application in the CRARE process and availability of required input information, as described in Section 6.1 of the RAWPA (DOE 1992a).

The results from the fate and transport modeling provide predicted exposure-point concentrations of each COC over a future time period, at specified time intervals, at selected receptor locations. These exposure-point concentrations are then used as the basis for characterizing risk (see Section H.4.0). Figure H.3-1 presents the fate and transport modeling process used in this CRARE.

H.3.2 GENERAL TECHNICAL APPROACH OF CRARE MODELING

This section describes the technical approach for determining the impacts to hypothetical receptors from residual COCs migrating through FEMP air, soil, surface water, and groundwater. Also presented are the effects of the remedial actions for each operable unit on the future site conditions, COC sources, and COC migration pathways. More information is provided in Attachments H.I and H.II.

H.3.2.1 Future Site Conditions

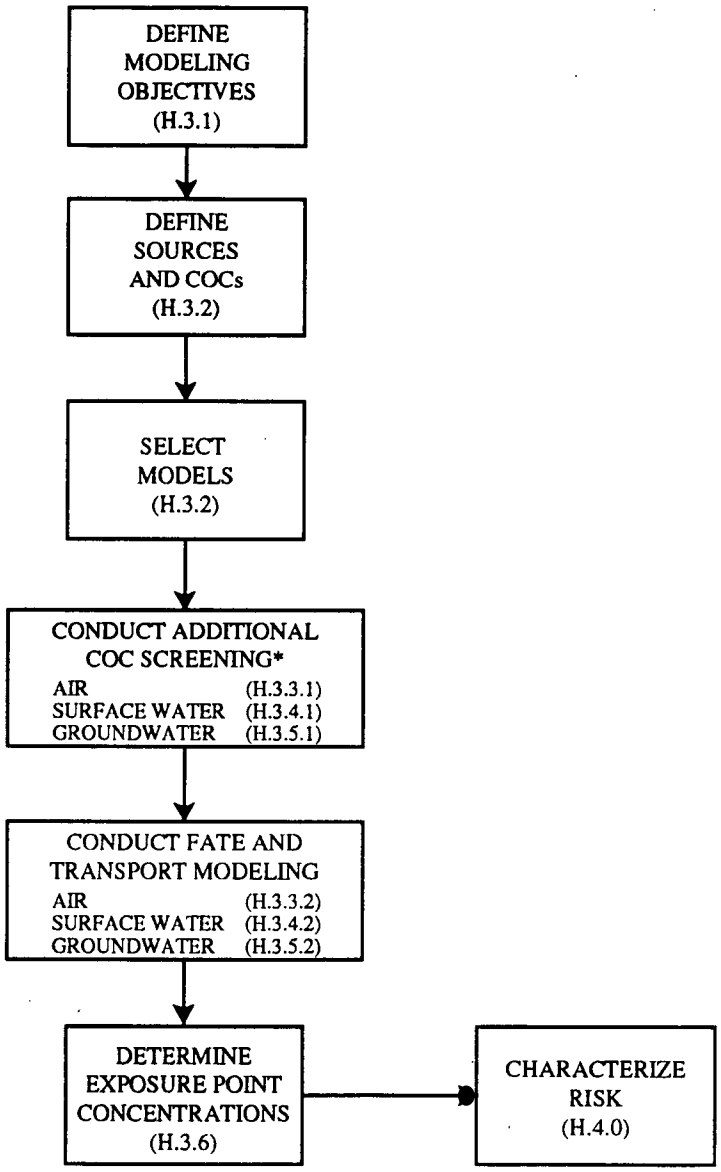
CRARE fate and transport modeling begins when all remedial actions for the five operable units have been completed, currently estimated to be about 30 years from now, and lasts for 1000 years. The general surface and subsurface conditions at the FEMP and surrounding area, projected to exist after the remedial actions have been completed, are described below. These site conditions will directly affect residual contaminant migration. The changes from the current conditions are reflected in the fate and transport models.

Surface Conditions

Future surface conditions, including vegetative coverage, dust emission, and runoff control, are important factors in determining the potential for residual contaminant migration in both the air and surface water pathways. The surface conditions also affect the infiltration rate of precipitation to the Great Miami Aquifer, which determines the rate of contaminant migration through the overburden.

For modeling purposes, the future ground cover at the FEMP is assumed to be similar to a meadow covered with "good" grass. A meadow is described as continuous grass protected from grazing and generally mowed for hay (USDA 1986). The grass cover of a meadow would be similar to a park. The undeveloped park and the disposal cell would likely be covered with combinations of woods, grass, and brush. The woods and brush are hydrologically similar to a meadow covered with grass. An 85 percent vegetative cover was assumed to be present at the site to support the undeveloped-park scenario. A ground cover is considered in "good" condition if it contains more than 75 percent vegetative cover (USDA 1986).

The ground is assumed to be regraded after completion of the remedial actions so that all surface runoff originating from the site flows toward Paddys Run. However, no other storm water runoff



* ADDITIONAL COC SCREENING BASED ON 95 PERCENT OF TOTAL RISK AND WATER CRITERIA FOR SURFACE WATER AND GRAOUNDWATER.

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FIGURE H.3-1. CRARE FATE AND TRANSPORT MODELING

control, such as a retention basin, would be in operation. The only structure remaining at the FEMP after completion of the remedial actions will be the disposal cell.

Subsurface Conditions

Future subsurface conditions will not vary significantly from current conditions except in areas where deep excavations (i.e., more than 10 feet) in the overburden are required as part of soil or perched groundwater remedial actions. Backfilled soil is assumed to have a lower permeability than existing natural overburden soil. Due to excavation and backfill, the existing major, high-yielding, perched-groundwater zone (i.e., capable of sustaining 1 gpm of pumping) under the former production area will no longer be able to sustain a high yield. Areas where the gray clay layer has been disturbed or removed during past constructions (e.g., storm water retention basins and Plant 6 basement) are assumed to be backfilled with additional clay materials to inhibit the leakage of residual contamination into the Great Miami Aquifer. However, to be conservative, the current definition of the general infiltration zones and infiltration rates through the overburden (see Appendix F, Section F.2.2) were not revised for the purposes of fate and transport modeling for the site-wide remedy.

Groundwater flow conditions in the Great Miami Aquifer would also be affected during the groundwater remediation period. However, the postremedial hydraulic conditions are not expected to change significantly in the Great Miami Aquifer from the preremedial conditions. The only major pumping operation in the Great Miami Aquifer is assumed to be the Southwest Ohio Water Company (SOWC) production wells, which were simulated using a higher projected pumping rate (i.e., 25 mgd) as used in the draft RI report (DOE 1994f).

H.3.2.2 COC Migration Pathways

Residual COCs can migrate through multiple media pathways and impact potential receptors as shown in Figure H.3-2. These pathways have been the subject of Operable Unit 5 RI studies (DOE 1994f) under the no-action scenario. Understanding the physical and chemical processes which control COC migration in these pathways is the basis for determining acceptable remedial alternatives in the FS. The Operable Unit 5 FS focuses on the effects that remedial actions will have on contaminant migration in each of the pathways, and factors pathway-specific protective requirements into the remedial components. The CRARE modeling incorporates the effects of the adopted site-wide remedy on the residual contamination and migration pathways.

To simulate contaminant migration in the postremedial environmental media, changes to hydrogeological and geochemical conditions caused by remedial actions and the effectiveness of the

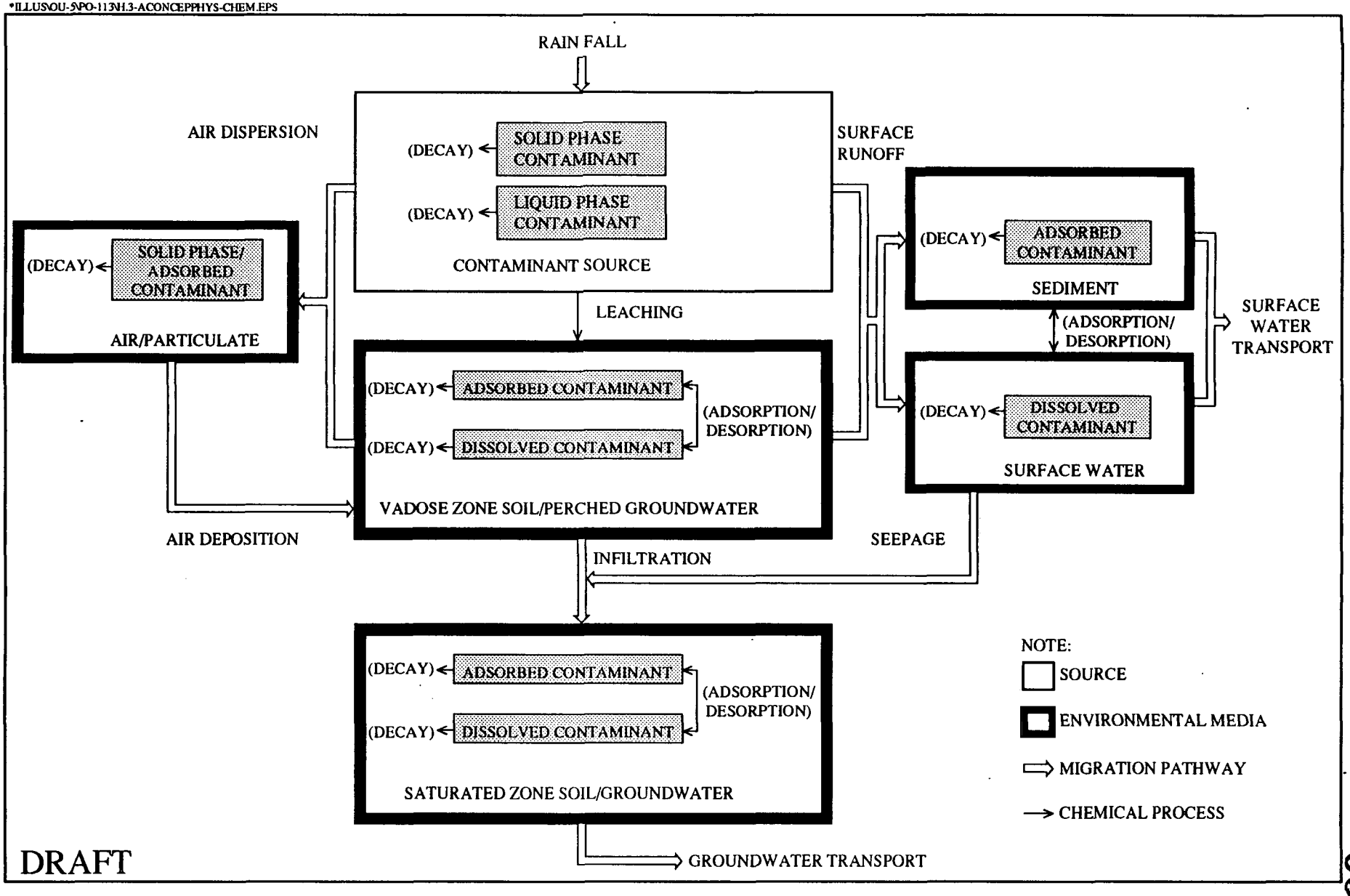

FIGURE H.3-2. PHYSICAL AND CHEMICAL PROCESSES OF CONTAMINANT FATE AND TRANSPORT

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engineered on-site disposal cell are all evaluated through modeling. The disposal cell and environmental media are sources of future residual contamination. The sources evaluated by the CRARE include:

- Air within and in the immediate vicinity of the FEMP
- The Great Miami Aquifer underlying and downgradient of the FEMP
- Surface water, sediment, and soil within and in the immediate vicinity of the FEMP
- Subsurface soil and perched groundwater in the FEMP
- The on-site disposal cell

After remedial actions, contaminants from these sources may be transported through the following pathways:

- Air emission:
  - Wind erosion of contaminated surface particulate matter, and the direct release of radon gas
- Surface water runoff:
  - Erosion of contaminated surface soil which is not excavated or covered into Paddys Run and the SSOD
  - Flow of contaminated surface runoff and sediment into the SSOD, Paddys Run, and the Great Miami River
- Groundwater transport:
  - Leaching of contaminants from the on-site disposal cell, residual contaminated soil, and perched groundwater through the overburden to the underlying Great Miami Aquifer
  - Infiltration of contaminated surface water from Paddys Run and the SSOD to the Great Miami Aquifer
  - Natural flow of groundwater in the Great Miami Aquifer which can carry dissolved residual contaminants and, potentially, contaminants adsorbed to colloidal particles of up to 2 microns in diameter

The CRARE fate and transport modeling encompasses these environmental media and pathways over an area large enough to cover all potentially major contaminant receptor locations identified in the Operable Unit 5 RI baseline risk assessment and shown in Figure H.3-3. Future conditions at these receptor locations were predicted by fate and transport modeling to support the CRARE residual risk assessment and to quantify the effects of remedial actions in the adopted site-wide remedy.

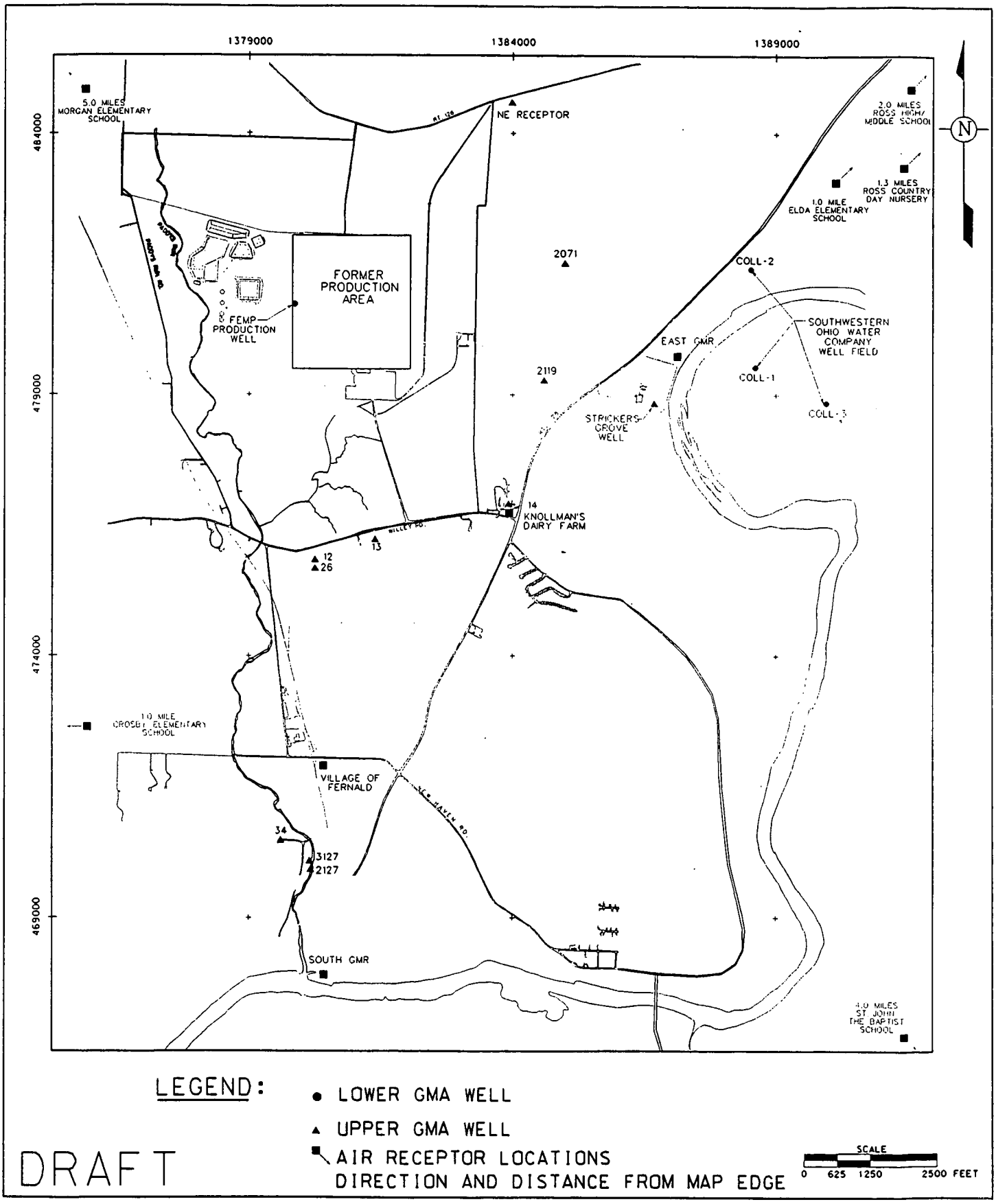

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FIGURE H.3-3. RECEPTOR LOCATIONS USED TO SUPPORT OU5 BASELINE RISK ASSESSSMENT

H.3.2.3 Selection of COC Species for Modeling

All the COCs identified in Appendix F (Section F.2.2), which have relatively high mobility and are still present at significant residual concentrations after remedial actions, were evaluated in the CRARE fate and transport modeling. The criteria for defining high mobility and significant concentrations are pathway-specific. For air and surface water pathways, the protective requirements developed in Appendix F (Section F.4.0) were used to screen the COCs. Those COCs with concentrations present above the protective requirement for air and surface water were evaluated for the respective pathways. The 19 constituents identified in the Operable Unit 5 draft RI (i.e., 18 COCs in Table 5-22 plus trichloroethene), which have the potential to migrate through the overburden within a 1000-year time frame or which have been detected in the Great Miami Aquifer at concentrations higher than drinking water criteria, were evaluated in the groundwater pathway.

H.3.2.4 Estimation of Residual Source Terms

For CRARE modeling purposes, residual contaminant sources are categorized into four major types: 1) residual contaminated soil, 2) perched groundwater, 3) Great Miami Aquifer groundwater, and 4) the on-site disposal cell. Representative COC concentrations and total masses were estimated for each type of residual source, based on the following type-specific approaches.

Residual Contaminated Soil

The contaminant source areas defined in the Operable Unit 5 draft RI were used as the basis for defining the residual soil contamination. In general, the original source concentrations used in the RI remain the same except for areas that will be excavated under the adopted site-wide remedy. In the CRARE, COC-specific background concentrations were assigned to the excavated source areas for inorganics. For special cases in which only portions of an original source area are excavated, representative contaminant concentrations for the remaining unexcavated portion were recalculated.

The initial excavation limits in the adopted site-wide remedy (as shown in Figure H.3-4) were compared to the contaminant source areas shown in Figure H.3-5 to determine which source areas would be excavated, partially excavated, or left unexcavated. Figure H.3-5 also includes additional source areas identified during the refinement process for the adopted site-wide remedy (see Section H.3.2.5) that would be excavated. Table H.3-1 lists the COC source areas which would be completely excavated and backfilled with clean soil. Four areas (NEb, 570a, 581a, and 582a) are assumed to be partially excavated. (Note: these additional excavations have been considered in the determination of footprints and volumes per media discussed in Section 2.0 of the FS report).

The representative concentrations for these areas are based on an area-weighted average of the background concentration (for the excavated portion) and the representative source concentration used in the Operable Unit 5 RI (for the unexcavated portion). When the excavation covered a significant

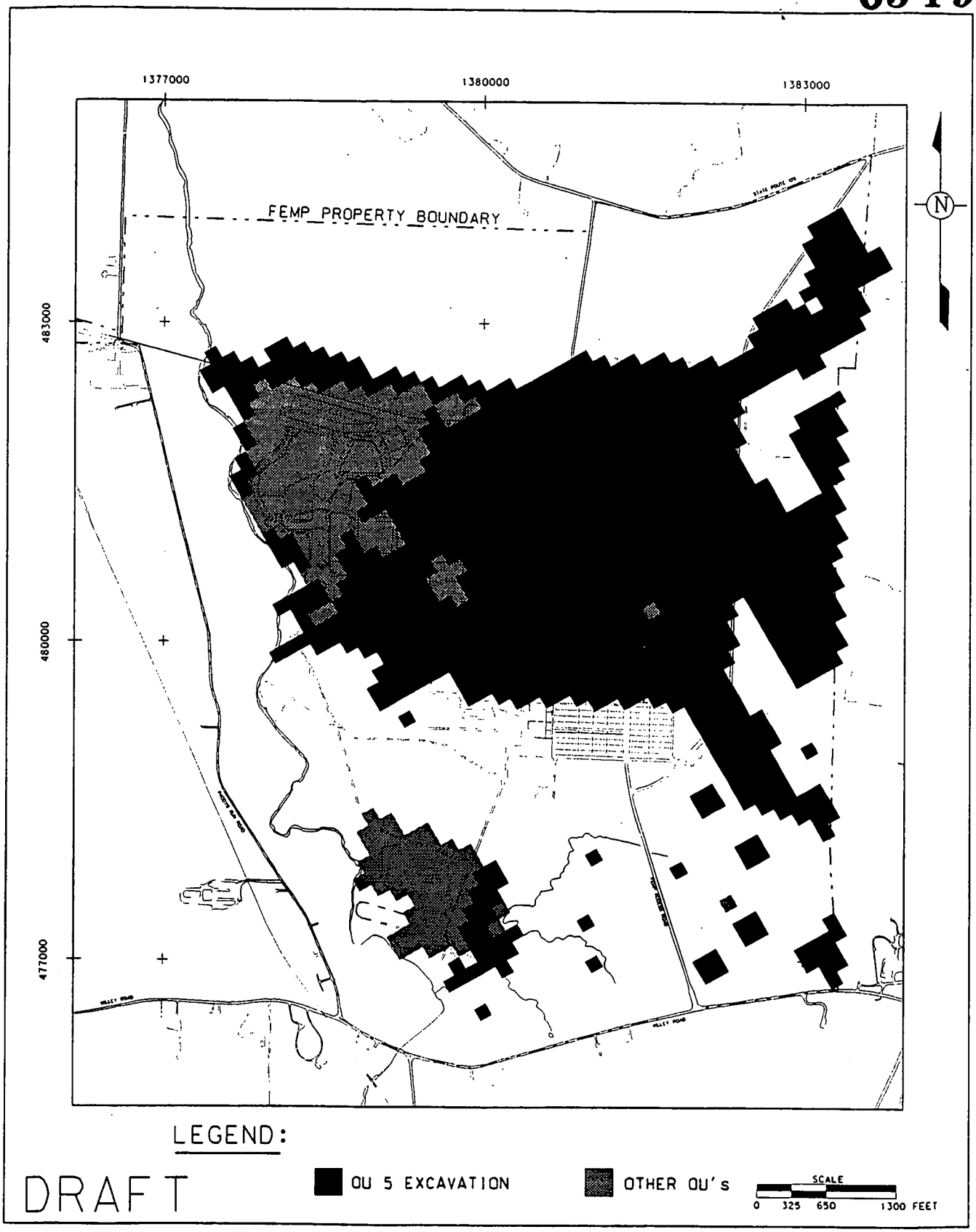

FIGURE H.3-4. INITIAL EXTENT OF SOIL EXCAVATION IN THE ADOPTED SITE-WIDE REMEDY

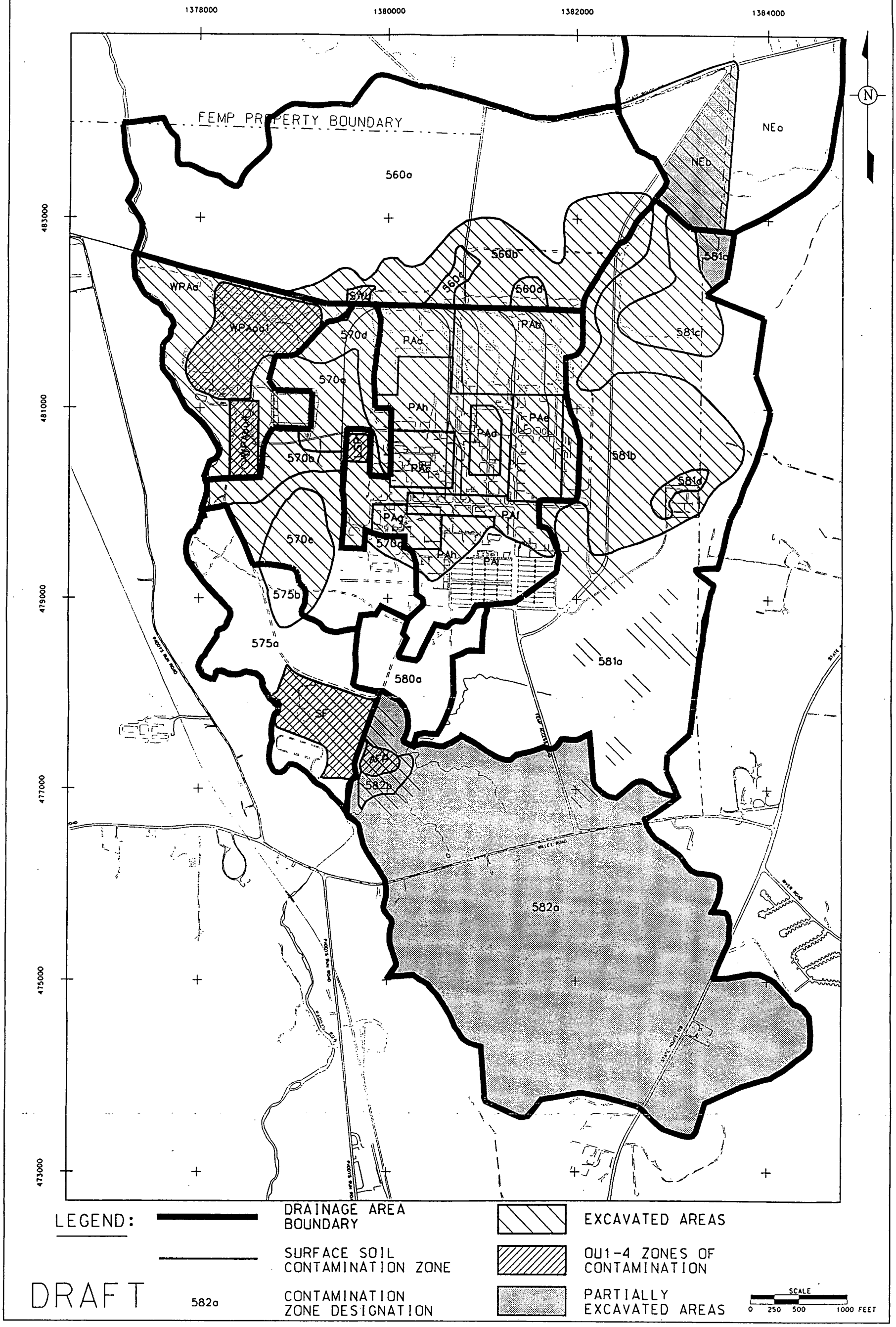

FIGURE H.3-5. COC SOURCE AREAS AND AREAS OF EXCAVATION

portion of the source or sampled area, the highest concentration of the soil samples in the unexcavated portion was used as the representative concentration for the source area. This yields a conservative (high) representative source concentration for the unexcavated areas. For the source areas in which no excavation is needed, the representative source concentrations from the Operable Unit 5 draft RI report were used in the modeling directly.

For the major COCs, block-by-block (i.e., every 125-foot by 125-foot area) residual source concentrations were statistically calculated. For the modeling, these concentrations were used to determine the level of conservatism of the original area-wide representative source concentrations as defined in the Operable Unit 5 draft RI report. In general, because of the small amount of sample data available in each area, the RI area-specific representative source concentrations (i.e., the UCL of the sample data) for most of the COCs were dominated by a few higher hits in each area. The actual areal extent of the contaminated area with these higher concentrations may be only a small portion within each source area. Therefore, using these RI representative concentrations directly is very conservative.

The residual soil contamination source terms used in the CRARE modeling for radionuclides in the surface and groundwater pathways do not include the background amount of contamination; that is, the background concentrations were subtracted from the subbasin average source terms. This was done because the protective requirements for radionuclides are for the incremental concentrations above the background. Also, the background contaminant mass does not readily leach and create significant cross-media impacts. Background concentrations for inorganics, however, are included in the modeling.

TABLE H.3-1

CONTAMINANT SOURCE AREAS EXCAVATED UNDER THE REPRESENTATIVE REMEDIAL ALTERNATIVE

Central	North	West	East	South
PAa	560b	570a (partial)	581a (partial)	582a (partial)
PAb	560c	570b	581b	582b
PAc	560d	570c	581c	
PAd	NEb (partial)	570d	581d	
PAe		570e		
PAf		WPAa		
PAg				
PAh				

Perched Groundwater

Perched groundwater contamination within the Zone V area (see Appendix F, Section F.2.2), which will not be excavated, was incorporated as residual contaminant sources in the groundwater pathway. The extent of the excavation in the perched groundwater zone is defined in Appendix F (Section F.6) and Section 2.0 of the FS report. Both the liquid- and solid-phase contaminant masses of residual perched groundwater contamination are accounted for in the CRARE modeling.

Great Miami Aquifer Groundwater

Those COC concentrations remaining in the Great Miami Aquifer after pump and treat operations were included in the initial conditions of the groundwater model to predict impacts due to future migration of these contaminants. Among the eight COCs modeled in the Great Miami Aquifer to develop the recovery well systems (i.e., Np-237, Ra-226, Tc-99, uranium, antimony, arsenic, manganese, and total VOC), only arsenic, manganese, and Ra-226 are expected to have groundwater concentrations higher than cleanup criteria in relatively small areas in the aquifer after contaminations of the other more mobile COCs are remediated. However, the impact of these residual COCs is relatively small and is not expected to migrate significantly.

Disposal Cell

COC-specific total masses and average concentrations in the on-site disposal cell were estimated and used in the groundwater modeling. The three-dimensional solid block modeling results were used to determine the volume-weighted uranium concentration in the disposal cell. All the model blocks that have uranium concentrations higher than soil PRLs, but lower than the WAC, were included in the calculation. Solid block modeling was not conducted for any other COC due to limitations in the available data.

Representative source concentrations in the disposal cell for other COCs (except Tc-99) were determined by calculating the volume-weighted RI representative source concentrations of excavated Operable Unit 5 source areas with higher contamination levels. Thirteen source areas (560c, 570a, 570b, 570d, 581d, PAa, PAb, PAc, PAd, PAe, PAf, PAg, and PAh) were included in these calculations. Excavated soil from these areas will primarily be disposed in the disposal cell unless contaminant concentrations exceed the WAC. The area- and COC-specific representative concentrations of these areas are presented in the Operable Unit 5 draft RI report (Appendix F). Additional statistical analyses using the original sampling data were also performed to verify that these calculated representative concentrations are conservative. In general, the COC-specific, volume-weighted concentrations using the RI area-specific source terms are slightly higher than the statistically calculated representative concentrations with all the sampling data in the excavated volume combined together.

Because of the high mobility of Tc-99 in the media, all soil with significant Tc-99 concentrations (i.e., 30 pCi/g or higher) that dominate the values of most area-specific RI source terms need to be disposed off-site under the limiting WAC. Therefore, the area-wide RI source terms cannot be used directly to determine the concentrations for Tc-99 contaminated soil to be left on site. Statistically calculated representative concentrations, with all the sampling data in the excavated volume that have concentrations less than 30 pCi/g, were used as the representative Tc-99 source concentration in the disposal cell. This approach provides a more realistic estimate of the Tc-99 concentration of materials actually left in the disposal cell.

The volumes of contaminated soil and material from other operable units were added to the total volume in the disposal cell. About 345,000, 158,000, and 3000 cubic yards of contaminated material directly from Operable Units 2, 3, and 4, respectively, were assumed to be placed in the on-site disposal cell. The estimated additional amounts of residual soil that Operable Unit 5 will excavate from Operable Units 1, 3, and 4 to satisfy the final PRLs are about 81,816, 23,300, and 29,630 cubic yards, respectively. COC-specific average concentrations of these materials were compared to the representative concentrations calculated using the Operable Unit 5 contaminated soil. However, the representative concentrations in the disposal cell were not recalculated if the concentrations from Operable Units 1 through 4 were lower than those calculated for Operable Unit 5 contaminated soil. In general, the COC-specific average concentrations from Operable Units 1 through 4 are lower than or similar to the Operable Unit 5 values. For example, the estimated average concentrations of uranium are 78 and 96 mg/kg from Operable Units 2 and 3, respectively. An average of 100 mg/kg is estimated for Operable Unit 5 contaminated soil in the disposal cell. All the COC-specific source concentrations in the disposal cell estimated for modeling are discussed in Section H.3.5.

H.3.2.5 Summary of Refinements to Operable Unit 5 Source Term Estimations and the Adopted Site-Wide Remedy

Based on the initial estimates of residual contaminant source concentrations (Section H.3.2.4), postremedial COCs and their impacts through each migration pathway were identified by screening level modeling. In screening level modeling, the COCs were evaluated in each of the migration pathways. The concentrations estimated in the pathways were compared to protective requirement concentrations. Those COCs exceeding the specified requirements were then further evaluated for the specific pathway. This information was used to refine the adopted site-wide remedy. The refinements were taken into consideration with the volume and footprint estimates presented in Section 2.0 of this FS for each land-use objective at each risk range case.

When unacceptable residual impacts were identified in the screening process, additional soil excavations and/or source characterizations were incorporated into the original Operable Unit 5 remedial alternative, and the affected residual source terms were then updated. The final residual fate

and transport modeling were conducted using the refined residual contaminant sources. Attachment H.I lists the adjustments made during this refinement process.

H.3.2.6 Modeling Tools

Contaminant fate and transport models for air, surface water, and groundwater pathways were used to predict future contaminant concentrations at receptor locations. Details of the development of these models are documented in the following technical reports and the Operable Unit 5 draft RI report:

- Groundwater Modeling Report - Summary of Model Development (DOE 1993e)
- Groundwater Model Evaluation Report and Improvement Plan (DOE 1993f)
- Development and Application of the ECTran Model to Support the RI/FS at the FEMP (DOE 1993g)
- Surface Water Flow and Infiltration Model Summary Report (DOE 1993h)
- SWIFT Great Miami Aquifer Model - Summary of Improvement Report (DOE 1994j)

Figure H.3-6 shows the categories of residual source terms and linkages to various fate and transport models for the site-wide residual risk analysis conducted in the CRARE. Application of these models has also been demonstrated in the Operable Unit 5 draft RI report and Appendix F of this FS report.

Air Transport Models

All the air transport analyses were conducted in accordance with EPA guidance (EPA 1989c). Two emission models and an air dispersion model were used to estimate air emissions from each source and to calculate annual average concentrations and deposition rates at various receptor locations. One emission model predicts the quantity of exposed soil that would be resuspended by the wind (EPA 1985b), and the Radon Attenuation and Cover Optimization with Moisture Effects (RAECOM) model (NRC 1984) estimates the flux of Rn-222 gas from soil containing Ra-226. Particulate-phase contaminants examined in the first emission model include radionuclide, inorganic, and semivolatile organic contaminants. Air dispersion modeling conducted for CRARE exposure calculations used the Industrial Source Complex, Long-Term (ISCLT2), Version 2, model (EPA 1992a). A description of these models is included in Attachment H.II.

*ILLUSOU-5PO-113H.3A-CRARE F&T.EPS

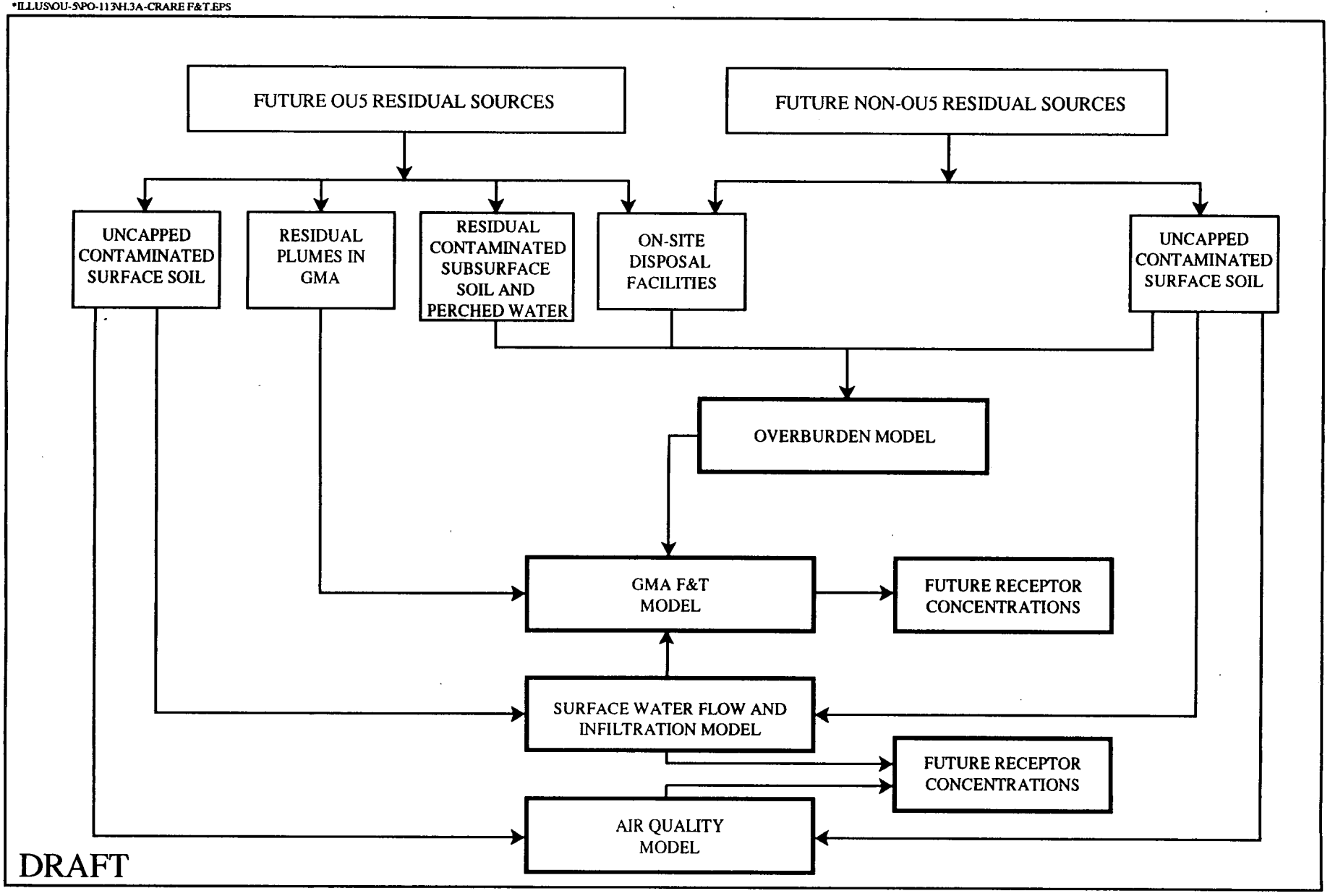

FIGURE H.3-6. CATEGORIES OF RESIDUAL SOURCE TERMS AND LINKAGES TO FATE AND TRANSPORT MODELS

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Surface Water Transport Model

Fate and transport modeling of surface water was conducted using the Surface Water Flow and Infiltration Model (SWF&IM, DOE 1993h) developed for the FEMP. The SWF&IM combines FEMP-specific hydrological conditions and several hydraulic and transport models used to simulate the various physical and chemical processes involved in the transport of contaminants from surface soil into surface water and infiltration through streambeds into the Great Miami Aquifer. The models which comprise the SWF&IM and their connections are described in detail in the documents referenced above. A summary of these models is presented in Attachment H.I.

Groundwater Transport Models

Groundwater models were used to predict flow and transport of constituents through the groundwater pathways. These models were the main tools used to develop cross-media PRGs, WAC, and remedial alternatives for the Great Miami Aquifer. They were also applied to support the CRARE residual risk assessment. A summary of these models used is presented in Attachment H.I. Revisions of the modeling approaches described in Appendix F (Section F.1.5.4) were also used in the CRARE groundwater modeling.

The groundwater transport models were classified as screening models or primary models. The primary models (SWIFT and ODAST/SWIFTLOAD) which cover the FEMP and its vicinity account for cumulative impacts from all the residual contaminant sources and predict future conditions to all the receptors in one simulation run. Primary models require very long computer run times and are not efficient for COC screening. Therefore, screening model (e.g., ECTran, DOE 1993g) was used to conduct the postremedial COC screening and preliminary evaluation of the disposal cell performance during the refinement of the representative alternative for Operable Unit 5. In general, the primary models were used to predict the cumulative residual impacts in the Great Miami Aquifer under the adopted site-wide remedy.

H.3.3 AIR PATHWAY MODELING APPROACH

The objective of the air quality impact analysis was to determine the maximum on- and off-property annual average ground-level air contaminant concentrations released from the remediated FEMP site. The ground-level air COC concentrations were then used in the exposure analysis to estimate risk to hypothetical receptors. A detailed discussion of the technical approach and results is presented in Attachment H.II. The general modeling approach is summarized below.

H.3.3.1 Constituents of Concern for Air Modeling

As described in Appendix F, (Section F.4), all the COCs in the surface soil pass the protective requirements set for the air pathway. However, the residual surface soil contamination of each COC listed in Appendix F (Section F.2), which accounted for 95 percent of the total risk associated with

the site before remedial actions, were evaluated in the air pathway for the CRARE to determined the residual risk.

H.3.3.2 Air Modeling Procedures

Air Emission and Dispersion Modeling

An EPA air quality dispersion model (EPA 1992a) was used to predict the airborne concentrations and deposition rates of contaminants emitted from the FEMP site. The results of the modeling were used in this CRARE to calculate risks to potential receptors. Rn-222 emission rates were estimated using the RAECOM model (NRC 1984). Airborne particulate emission rates were estimated using EPA methods (EPA 1985b). The residual COC soil concentrations were multiplied by the particulate matter emission rate to determine COC-specific emission rates for radionuclides, inorganics, and semivolatile organics.

Sources

The air emissions from FEMP surface soils were modeled as square-area sources for risk assessment calculations. In this CRARE, the minimum length of a side for a given area source in this analysis was set at 50 feet. The largest area sources in this analysis were 400 feet on a side. A total of 1306 sources were combined into 37 source groups. The air dispersion model assumes uniform contamination within a source group. Since the source of contamination in both the air pathway and surface water pathway is assumed to be the surface soil, the surface water source groups developed for the Operable Unit 5 draft RI report were adopted for this air pathway analysis.

The Waste Pit area has 57 sources; the South Field and Flyash Piles have 278 sources; the Solid Waste Landfill has 4 sources; the Lime Sludge Ponds have 4 sources; the silo area has 10 sources; the former production area has 183 sources; and the remainder of the FEMP has 770 sources. Some modifications were applied to the source groups used in the Operable Unit 5 draft RI report (Appendix F). These modifications for the air pathway analysis include:

- Source group 570a was split into north and south areas (two groups instead of one)
- Source group NEb was split into north and east areas (two groups instead of one)

As indicated above, models and methods were used to estimate air contaminant emission rates. Radon emissions were calculated using the RAECOM model. The contaminant concentrations in surface soil were used to develop suspended contaminant emission rates from the total suspended particulate emission rate. Contaminants in wind-blown soil include radionuclides, inorganic compounds, and organic compounds.

Contaminant concentrations in residual soil were estimated from soil PRLs and sampling results contained in the RI/FS database. The PRLs were used to set an upper limit on residual soil concentrations since soil with contaminant levels greater than the PRLs will be excavated. The RI/FS data were used to estimate surface soil concentrations for areas in which contaminant levels did not exceed PRLs. The RI/FS data used for air pathway modeling are the same as that used for surface water modeling. The excavated and backfilled areas were assigned with background concentrations as contaminant source terms for modeling.

Meteorological Data

Five years of meteorological data from the FEMP, in stability array (STAR) format, were used to model air quality impacts (1987, 1988, 1989, 1991, and 1992). The data collection efficiency for 1990 was below 90 percent and therefore that year was not used. The requirement of 90 percent efficiency for valid wind and stability data is defined in the U.S. EPA Quality Assurance Handbook for Air Pollution Measurements Systems (EPA 1989b). Based on this guidance and the professional judgement that missing 10 percent of the meteorological data could significantly impact the results, therefore, the 1990 data set was not used.

Receptors

Air contaminant concentrations were modeled using a receptor grid and a system of fenceline receptors. The receptor grid consists of 985 receptor points covering the site and extending approximately 1000 feet beyond the FEMP fenceline in each direction. The grid was used to develop airborne concentration isopleths for the FEMP and surrounding area. The maximum on-property contaminant concentrations were determined from modeled results at these receptor grid points.

The fenceline receptor system (a subset of the grid system) consists of 36 receptor points located around the FEMP along the fenceline. The maximum off-property impact location was determined from modeled results at these receptor points. The off-property residential exposure was developed from this maximum impact location (the nearest off-property resident was assumed to be at the maximum off-property impact location).

H.3.4 SURFACE WATER PATHWAY MODELING APPROACH

The objective of the CRARE surface water modeling was to determine the concentrations and movement of COCs from the remediated FEMP site through surface water. The following is a summary of the modeling procedures used. Additional information is presented in Attachment H.I.

H.3.4.1 Constituents of Concern for Surface Water Modeling

The COCs which failed either the surface water or sediment screening (see Appendix F, Section F.2) and which account for 95 percent of the total risk associated with the site were evaluated using the

surface water protective requirements as discussed in Appendix F (Section F.4.0). The surface water protective requirements were screened against the subbasin average concentration after remediation. If the subbasin average COC concentration was higher than the surface water protective requirement for any subbasin, then the COC was modeled for the CRARE. Only manganese failed the screening and required complete surface water modeling for the CRARE after refining the original footprint for the adopted site-wide remedy (see Section H.3.2.5). These screening results are presented in Appendix F, Section F.4). Uranium was also modeled, even though it passed the protective requirement screening because it is the most prominent contaminant at the site before the proposed remedial actions.

The surface water contaminant loading terms to the Great Miami Aquifer for all of the 17 COCs identified in Appendix F (Section F.2), which also failed either the surface water or sediment screening were estimated. The surface water mass loadings for all of these COCs were calculated because most of them were also required in the CRARE groundwater modeling. Surface water represents a portion of the groundwater pathway since COCs in surface water are assumed to infiltrate to groundwater and then may be transported in the groundwater to potential receptors.

H.3.4.2 Surface Water Modeling Procedures

As stated above, the surface water modeling for the CRARE used the SWF&IM. The surface water modeling for the CRARE assumed that all remedial actions at the site have been completed and that the surface water controls at the site are no longer functioning. The site was assumed to be covered with good grass as discussed in the assumptions for the development of the protective requirements in Appendix F (Section F.4). The surface cover of good grass is consistent with the assumed land use as an undeveloped park. The final cover condition was assumed to contain an 85 percent cover for purposes of fate and transport modeling. The remediation of the site under the adopted site-wide remedy will require excavation of significant areas of the surface soils. The excavated areas will be backfilled with clean soil which contains background levels of contamination.

The surface water modeling input parameters are the same as those used in the development of the surface water protective requirements as described in Appendix F (Section F.4). For uranium, a K_t of 325 L/kg was used for all areas since the areas of higher uranium solubility (K_t of 15 L/kg) will all be excavated and backfilled with clean soil under the adopted site-wide remedy.

H.3.5 GROUNDWATER PATHWAY MODELING APPROACH

The purpose of the CRARE groundwater modeling was to predict the concentrations and movement of COCs in groundwater from source areas (e.g., soil, perched water, and disposal cell) to receptors. A summary of the modeling procedures is presented below. Additional information is presented in Attachment H.I.

H.3.5.1 Constituents of Concern for Groundwater Modeling

The 19 constituents identified in the Operable Unit 5 draft RI report, which have the potential to migrate through the overburden within a 1000-year time frame or have been detected in the Great Miami Aquifer at concentrations higher than drinking water criteria, were evaluated in the groundwater pathway. However, only 14 of these COCs were found to have the potential to migrate through the overburden under the natural conditions as indicated in Appendix F (Section F.2).

Unlike the air and surface water pathways, which use background surface soil conditions, Source Areas 560b, 581a, and 581c will still have about 0.5-foot of subsurface residual contamination in the groundwater modeling. This remaining subsurface soil contamination is assumed because subsurface contaminated soil may not be completely excavated in these three areas as part of the adopted site-wide remedy. All the area-specific residual COC concentrations, surface water mass loadings, and source terms for the on-site disposal cell used in the CRARE groundwater modeling are presented in Attachment H.I. For modeling purposes, COC source terms in the disposal cell, other than the 14 COCs that have the potential to migrate through the overburden (Appendix F, Section F.2) were not calculated and are specified as zero in Attachment H.I.

H.3.5.2 Groundwater Modeling Procedures

The groundwater fate and transport modeling conducted for this CRARE required the use of several modeling components to determine the vertical transport of COCs in the soil and perched water to the Great Miami Aquifer, to simulate future COC loading from the on-site disposal cell, and to define future COC concentrations at receptor locations defined in the Operable Unit 5 RI report. Below is a discussion of the procedures used to meet these objectives.

As part of the refinement process, the ODAST/SWIFTLOAD modeling used the residual COC mass from the Operable Unit 1 FS to determine the vertical migration of residual COCs in the Waste Pit Area to the groundwater. However, because the Operable Unit 5 representative alternative does not include capping for these areas, the natural infiltration rates without capping were used for this modeling. The results of this modeling effort were used to determine additional area and volume of soil to be excavated by Operable Unit 5.

The ECTran model was used to simulate future COC loadings from the on-site disposal cell. The results of this modeling effort were used to identify any COCs that may not be acceptable in the cell. Attachment H.I presents the results of the screening and the COC-specific source terms for the disposal cell. The ECTran model was also used to conduct a conceptual long-term performance evaluation of the on-site disposal cell by performing Monte Carlo simulations. Detailed procedures and results of this evaluation are presented in Appendix F (Section F.5.5.6).

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The residual contamination of the 19 COCs in soil, perched water, and the Great Miami Aquifer, and mass loadings from surface water and the disposal cell were incorporated into the ODAST/SWIFTLOAD model. The mass loading rate and leachate concentrations reaching the Great Miami Aquifer groundwater table were determined from the model simulations. Any COCs that were found to have leachate concentrations at least twice the drinking water criteria were considered postremedial COCs for modeling purposes.

The COCs that failed the ODAST/SWIFTLOAD screening, or would be present at unacceptable initial conditions in the Great Miami Aquifer after 30 years of groundwater remedial action, were further evaluated using the SWIFT Great Miami Aquifer model. The SWIFT Great Miami Aquifer model was run for a 1000-year time period after remediation to define future COC concentrations at all selected receptor locations defined in the Operable Unit 5 RI report.

H.3.6 SUMMARY OF MODELING RESULTS

The results of the CRARE fate and transport modeling are presented in this section. The exposure-point concentrations determined from the modeling were used to estimate risk to potential receptors (see Section H.4.0).

H.3.6.1 Air Results

The modeled maximum annual average COC air concentrations are presented in Tables H.3-2 through H.3-4. The values presented in Table H.3-3 are the maximum on-property COC concentrations, and the values presented in Table H.3-3 are the fenceline COC concentrations. The modeled off-property air concentrations due to off-property soil contamination are presented in Table H.3-4. Total and background air concentrations are included on each table. Based on the results presented in the Operable Unit 4 CRARE (DOE 1993b), the maximum off-property concentrations were used to represent average on-property concentrations for receptors that were assumed to roam or wander about the property.

Modeled concentrations of U-238 represented typical particulate-phase, radionuclide activity. The maximum total on-property and fenceline concentrations of U-238 were modeled at 3.87×10^{-6} and 3.56×10^{-6} pCi/m^3, respectively. Residual concentrations in air, above background, are 3.18×10^{-6} and 2.96×10^{-6} pCi/m^3, respectively, for maximum on-property and fenceline impacts.

Modeled air concentrations of gaseous Rn-222 on property and at the fenceline were 22.0 and 11.3 pCi/m^3, respectively, based on total residual Ra-226 soil concentrations. After correcting for background Ra-226 soil concentrations, the on-property and fenceline Rn-222 concentrations were modeled at 10.7 and 1.84 pCi/m^3, respectively.

TABLE H.3-2

PROJECTED MAXIMUM ON-PROPERTY RESIDUAL COC CONCENTRATIONS IN AIR DUE TO RESIDUAL ON-PROPERTY SOIL CONTAMINATION

	Concentrations in Air	
COC	Total	Background
Inorganics (μg/m3)		
Antimony	2.79×10^{-6}	2.33×10^{-6}
Arsenic	3.86×10^{-6}	3.55×10^{-6}
Beryllium	4.56×10^{-7}	3.83×10^{-7}
Cadmium	3.91×10^{-7}	3.32×10^{-7}
Magnesium	5.71×10^{-3}	1.23×10^{-3}
Manganese	5.21×10^{-4}	5.19×10^{-4}
Mercury	1.71×10^{-7}	1.91×10^{-7}
Silver	1.32×10^{-6}	1.40×10^{-6}
Uranium-Total	1.16×10^{-5}	2.09×10^{-6}
Organics (μg/m3)		
Aroclor-1254	5.27×10^{-8}	0.00
Benzo(a)pyrene	1.28×10^{-8}	0.00
Trichloroethene	7.70×10^{-10}	0.00
Radionuclides (pCi/m3)		
Ra-226	1.57×10^{-6}	7.78×10^{-7}
Rn-222	2.20×10^{1}	1.13×10^{1}
Sr-90	2.38×10^{-7}	1.59×10^{-7}
Tc-99	1.59×10^{-7}	0.00
Th-230	1.80×10^{-6}	9.57×10^{-7}
Th-232	6.97×10^{-7}	6.89×10^{-7}
U-235/236	5.27×10^{-8}	5.74×10^{-8}
U-238	3.87×10^{-6}	6.89×10^{-7}

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TABLE H.3-3

PROJECTED MAXIMUM FENCELINE RESIDUAL COC CONCENTRATIONS IN AIR DUE TO RESIDUAL ON-PROPERTY SOIL CONTAMINATION

	Concentrations in Air	
COC	Total	Background
Inorganics (μg/m3)		
Antimony	2.02×10^{-6}	2.02×10^{-6}
Arsenic	3.16×10^{-6}	3.07×10^{-6}
Beryllium	3.46×10^{-7}	3.32×10^{-7}
Cadmium	3.03×10^{-7}	2.87×10^{-7}
Magnesium	1.84×10^{-3}	1.07×10^{-3}
Manganese	4.46×10^{-4}	4.50×10^{-4}
Mercury	1.48×10^{-7}	1.66×10^{-7}
Silver	1.13×10^{-6}	1.22×10^{-6}
Uranium-Total	1.07×10^{-5}	1.81×10^{-6}
Organics (μg/m3)		
Aroclor-1254	1.58×10^{-8}	0.00
Benzo(a)pyrene	1.11×10^{-8}	0.00
Trichloroethene	4.42×10^{-10}	0.00
Radionuclides (pCi/m3)		
Ra-226	8.16×10^{-7}	6.74×10^{-7}
Rn-222	1.13×10^{1}	9.46×10^{0}
Sr-90	1.86×10^{-7}	1.38×10^{-7}
Tc-99	1.38×10^{-7}	0.00
Th-230	1.25×10^{-6}	8.29×10^{-7}
Th-232	6.01×10^{-7}	5.97×10^{-7}
U-235/236	4.65×10^{-8}	4.97×10^{-8}
U-238	3.56×10^{-6}	5.97×10^{-7}

TABLE H.3-4

PROJECTED MAXIMUM OFF-PROPERTY RESIDUAL COC CONCENTRATIONS IN AIR DUE TO RESIDUAL OFF-PROPERTY SOIL CONTAMINATION

	Concentrations in Air	
Contaminant	Total	Background
Inorganics (μg/m3)		
Antimony	2.94×10^{-7}	8.24×10^{-7}
Arsenic	8.55×10^{-7}	1.26×10^{-6}
Beryllium	1.01×10^{-7}	1.35×10^{-7}
Cadmium	1.11×10^{-7}	1.17×10^{-7}
Magnesium	4.95×10^{-4}	4.36×10^{-4}
Manganese	1.46×10^{-4}	1.84×10^{-4}
Mercury	1.24×10^{-8}	6.77×10^{-8}
Silver	1.08×10^{-7}	4.97×10^{-7}
Uranium-Total	1.62×10^{-6}	7.38×10^{-7}
Organics (μg/m3)		
Aroclor-1254	4.97×10^{-9}	0.00
Benzo(a)pyrene	4.51×10^{-9}	0.00
Trichloroethene	4.51×10^{-10}	0.00
Radionuclides (pCi/m3)		
Ra-226	2.03×10^{-7}	2.75×10^{-7}
Rn-222	2.63×10^{0}	1.36×10^{1}
Sr-90	5.98×10^{-8}	5.64×10^{-8}
Tc-99	2.74×10^{-7}	0.00
Th-230	3.98×10^{-7}	3.39×10^{-7}
Th-232	2.00×10^{-7}	2.44×10^{-7}
U-235/236	2.53×10^{-8}	2.03×10^{-8}
U-238	5.42×10^{-7}	2.44×10^{-7}

The maximum annual fenceline concentrations of several radionuclides measured during 1991 and 1992 (DOE 1993c) are presented in Table H.3-5. A comparison of modeled future fenceline concentrations with currently measured values indicates that site remediation would result in reducing off-property air impacts by 1 to 2 orders of magnitude.

H.3.6.2 Surface Water Results

The results from the surface water modeling indicate concentrations for manganese in the groundwater (via the surface water infiltration) and sediment fail the PRG (0.2 HQ) for the on-property resident farmer (groundwater) and the undeveloped park user (sediments). Attachment H.I presents the future surface water and sediment concentrations for all modeled surface water COCs. The subbasin average surface soil concentrations for manganese for each subbasin are close to the background soil concentrations (within the range of the background surface soil data). If the background concentration were input into the surface water model for manganese for all of the source areas, manganese would still not meet the PRG in the groundwater and sediments. The origin of the widespread manganese concentrations in soil is unclear and not supported by FEMP processing history. The uranium concentrations are all below PRL ($1x10^{-5}$ ILCR) for the same risk scenarios.

Table H.3-6 presents the surface water COC loading to the Great Miami Aquifer of all of the COCs which account for 95 percent of the total risk and/or failed either the surface water or sediment screening as presented in Appendix F (Section F.2). The loadings from all of these COCs are calculated because they are required for the CRARE groundwater modeling.

H.3.6.3 Groundwater Results

Predicted groundwater concentrations are summarized in this section for selected receptor locations (locations are identified in the Operable Unit 5 draft RI report). The COC-specific maximum concentrations and the times of occurrence at each receptor location are listed in Tables H.3-7 and H.3-8 for on-property and off-property receptors, respectively. To estimate the cumulative impact due to multiple COCs, COC-specific concentrations at the time of the uranium maximum at each receptor location were also determined. These results are listed in Table H.3-9.

Contour maps were developed to show the COC-specific maximum concentrations identified for on- and off-property receptor locations (see Attachment H.I, Figures H.I.1-3 through H.I.1-14). The following observations were made based on these contour maps:

- The disposal cell will not have any significant impacts to the Great Miami Aquifer in the 1000-year time frame.

TABLE H.3-5

ANTICIPATED AIR COC CONCENTRATION REDUCTIONS AT FENCELINE AFTER COMPLETION OF REMEDIAL ACTIVITIES

Radionuclide	Modeled Conc. (pCi/m^3)	Monitored Conc. (pCi/m^3) 1991	Monitored Conc. (pCi/m^3) 1992	Anticipated Reduction (%)
Ra-226	8.16×10^{-7}	$< 5.9 \times 10^{-5}$	1.0×10^{-4}	98-99
Ra-222	1.13×10^{1}	3.1×10^{2}	1.7×10^{2}	93-96
Sr-90	1.86×10^{-7}	$< 7.8 \times 10^{-5}$	No Data	99
Tc-99	1.38×10^{-7}	1.5×10^{-5}	1.1×10^{-3}	99
Th-230	1.25×10^{-6}	2.1×10^{-5}	$< 3.3 \times 10^{-5}$	94-96
Th-232	6.01×10^{-7}	1.3×10^{-5}	$< 4.0 \times 10^{-5}$	95-98
U-235/236	4.65×10^{-8}	7.4×10^{-6}	5.4×10^{-6}	99
U-238	3.56×10^{-6}	1.2×10^{-4}	9.8×10^{-5}	96-97

Source: DOE 1993i

TABLE H.3-6

SURFACE WATER PATHWAY LOADINGS (kg/yr) TO THE GREAT MIAMI AQUIFER

COCs	CD[a]	DE[a]	EF[a]	SSOD
Radionuclides				
Ra-226+8D	0.00	0.00	2.50×10^{-11}	1.12×10^{-9}
Sr-90+1D	3.37×10^{-9}	1.38×10^{-9}	2.46×10^{-10}	5.89×10^{-9}
Tc-99	1.14×10^{-3}	4.16×10^{-4}	3.33×10^{-5}	0.00
Th-230	2.89×10^{-8}	1.60×10^{-7}	1.46×10^{-8}	1.10×10^{-7}
Th-232+10D	0.00	0.00	2.51×10^{-5}	1.12×10^{-3}
Inorganics				
Antimony	6.31×10^{-2}	2.92×10^{-2}	3.95×10^{-3}	6.41×10^{-2}
Arsenic	3.50×10^{-1}	1.95×10^{-1}	3.35×10^{-2}	7.27×10^{-1}
Beryllium	7.20×10^{-3}	4.77×10^{-3}	7.65×10^{-4}	1.58×10^{-2}
Magnesium	2.78×10^{4}	1.94×10^{4}	1.84×10^{3}	1.21×10^{4}
Manganese	3.55×10^{1}	2.64×10^{1}	4.27×10^{0}	8.73×10^{1}
Mercury	2.31×10^{-1}	1.44×10^{-1}	2.73×10^{-2}	6.23×10^{-1}
Uranium	2.77×10^{-1}	2.02×10^{-1}	2.45×10^{-2}	3.73×10^{-1}
Organics				
Alpha-chlordane	0.00	0.00	9.98×10^{-6}	4.46×10^{-4}
Aroclor-1254	0.00	0.00	0.00	0.00
Aroclor-1260	0.00	0.00	0.00	0.00
Benzo(a)pyrene	4.24×10^{-6}	1.79×10^{-5}	1.64×10^{-6}	9.80×10^{-6}
Dibenzo(a,h)anthracene	0.00	0.00	0.00	0.00

[a] See Operable Unit 5 RI (Section F.2 of Appendix F) for definitions of Paddys Run reaches.
SSOD= Storm Sewer Outfall Ditch

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TABLE H.3-7

SUMMARY OF TIME, LOCATION, AND MAXIMUM GROUNDWATER CONCENTRATIONS OF COCs AT ON-PROPERTY LOCATIONS

COC	On-Site Maximum			On-Site Fenceline Maximum		
	Concentration (μg/L)	Time (yr)	Grid Location (I,J)	Concentration (μg/L)	Time (yr)	Grid Location (I,J)
Radionuclides						
Np-237	1.131×10^{-4}	0	46,80	9.716×10^{-6}	100	34,47
Ra-226	1.207×10^{-5}	0	30,84	1.382×10^{-6}	450	65,60
Sr-90	2.999×10^{-8}	140	47,55	6.545×10^{-9}	190	26,50
Tc-99	4.892×10^{-3}	40	28,68	1.261×10^{-3}	60	32,47
Inorganics						
Antimony	4.591×10^{-1}	1000	47,55	1.712×10^{-1}	1000	34,47
Arsenic	9.635×10^{1}	0	61,71	7.184×10^{1}	0	49,108
Boron	2.823×10^{2}	520	75,92	2.018×10^{2}	480	62,100
Magnesium	1.476×10^{5}	240	34,64	6.159×10^{4}	350	34,47
Manganese	1.054×10^{4}	0	23,14	4.089×10^{2}	0	73,73
Mercury	4.282×10^{0}	630	47,55	1.254×10^{0}	800	34,47
Uranium-Total	2.159×10^{1}	670	77,91	2.138×10^{1}	510	76,76
Organics						
Alpha-chlordane	2.467×10^{-2}	120	50,64	4.621×10^{-3}	140	61,53

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TABLE H.3-7
(Continued)

COC	East Boundary Concentration (μg/L)	East Boundary Time (yr)	East Boundary Grid Location (I,J)	West Boundary Concentration (μg/L)	West Boundary Time (yr)	West Boundary Grid Location (I,J)	North Boundary Concentration (μg/L)	North Boundary Time (Yr)	North Boundary Grid Location (I,J)
Radionuclides									
Np-237	2.694×10^{-6}	330	56,44	2.229×10^{-5}	0	22,70	1.730×10^{-11}	260	62,100
Ra-226	1.382×10^{-6}	450	65,60	1.193×10^{-6}	0	31,101	1.045×10^{-6}	0	46,110
Sr-90	8.440×10^{-10}	70	58,47	2.385×10^{-9}	170	22,69	3.719×10^{-17}	310	62,100
Tc-99	7.546×10^{-4}	30	57,46	1.056×10^{-3}	40	22,69	4.564×10^{-4}	50	62,100
Inorganics									
Antimony	8.263×10^{-2}	1000	54,40	5.842×10^{-2}	250	22,69	5.181×10^{-6}	50	62,100
Arsenic	3.019×10^{0}	300	69,66	3.252×10^{-1}	1000	22,69	7.184×10^{1}	0	49,108
Boron	9.577×10^{1}	610	84,88	4.750×10^{0}	290	22,70	2.018×10^{2}	480	62,100
Magnesium	3.223×10^{4}	530	54,40	2.583×10^{4}	300	22,69	3.254×10^{4}	720	62,100
Manganese	4.089×10^{2}	0	73,73	1.479×10^{2}	50	28,89	1.657×10^{0}	1000	61,99
Mercury	6.840×10^{-1}	1000	54,40	2.145×10^{-1}	710	22,69	3.445×10^{-3}	1000	55,105
Uranium-Total	2.124×10^{1}	520	75,75	1.797×10^{0}	0	26,84	7.934×10^{0}	640	62,100
Organics									
Alpha-chlordane	4.621×10^{-3}	140	61,53	1.453×10^{-9}	90	21,65	8.612×10^{-13}	150	62,100

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TABLE H.3-8

SUMMARY OF TIME, LOCATION, AND MAXIMUM GROUNDWATER CONCENTRATIONS OF COCs AT OFF-PROPERTY RECEPTOR LOCATIONS

Receptor Location:	Well 12		Well 12		Well 13		Well 13	
	(28,46,1)		(28,46,2)		(39,44,1)		(59,38,1)	
COC	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time
Radionuclides								
Np-237	4.10×10^{-6}	80	5.06×10^{-6}	90	8.00×10^{-6}	160	1.84×10^{-6}	430
Ra-226	2.20×10^{-7}	1000	1.00×10^{-7}	1000	1.40×10^{-9}	1000	1.10×10^{-8}	1000
Sr-90	4.56×10^{-9}	140	2.31×10^{-9}	150	2.60×10^{-9}	160	1.19×10^{-10}	210
Tc-99	9.95×10^{-4}	40	1.19×10^{-3}	40	1.04×10^{-3}	40	5.00×10^{-4}	40
Inorganics								
Antimony	1.32×10^{-1}	200	1.11×10^{-1}	300	1.47×10^{-1}	300	5.88×10^{-2}	650
Arsenic	1.07×10^{0}	0	5.92×10^{-1}	0	4.75×10^{-2}	200	1.21×10^{-2}	1000
Boron	1.26×10^{1}	40	5.90×10^{0}	50	9.81×10^{1}	170	3.63×10^{1}	350
Magnesium	4.99×10^{4}	380	4.97×10^{4}	990	5.58×10^{4}	370	2.09×10^{4}	600
Manganese	6.53×10^{1}	100	7.56×10^{1}	150	9.79×10^{1}	600	6.21×10^{0}	1000
Mercury	9.48×10^{-1}	970	6.78×10^{-1}	990	1.32×10^{0}	660	3.94×10^{-1}	1000
Uranium-Total	1.82×10^{0}	0	2.47×10^{0}	0	9.02×10^{0}	20	7.44×10^{0}	430
Organics								
Alpha-Chlordane	4.77×10^{-4}	60	2.50×10^{-4}	70	7.99×10^{-4}	90	2.01×10^{-3}	150

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TABLE 3-8
(Continued)

Receptor Location:	Well 34		Well 2071		Well 2119		Well 2127	
	(5,11,1)		(85,66,1)		(73,52,1)		(5,6,1)	
COC	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time
Radionuclides								
Np-237	4.39×10^{-6}	0	8.95×10^{-8}	450	7.32×10^{-7}	450	6.53×10^{-6}	0
Ra-226	1.50×10^{-9}	1000	1.10×10^{-25}	1000	1.00×10^{-6}	0	2.0×10^{-8}	1000
Sr-90	2.48×10^{-13}	290	9.34×10^{-12}	90	4.83×10^{-12}	260	2.34×10^{-12}	310
Tc-99	1.36×10^{-6}	80	1.04×10^{-4}	60	2.07×10^{-4}	40	1.43×10^{-5}	80
Uranium-Total	7.92×10^{-2}	0	5.61×10^{0}	600	4.00×10^{0}	410	3.52×10^{-1}	0
Inorganics								
Antimony	1.37×10^{-4}	500	1.47×10^{-3}	100	1.12×10^{-2}	100	1.43×10^{-3}	550
Arsenic	4.49×10^{-1}	50	4.58×10^{-1}	850	2.69×10^{-1}	1000	3.47×10^{0}	50
Boron	6.33×10^{-3}	410	1.06×10^{1}	700	1.64×10^{1}	340	7.33×10^{-2}	410
Magnesium	5.78×10^{1}	1000	3.64×10^{3}	990	8.61×10^{3}	530	6.02×10^{2}	1000
Manganese	2.22×10^{0}	850	1.66×10^{1}	1000	1.08×10^{1}	1000	1.90×10^{1}	800
Mercury	6.92×10^{-4}	1000	4.03×10^{-3}	1000	5.71×10^{-2}	1000	7.11×10^{-3}	1000
Organics								
Alpha-Chlordane	4.00×10^{-7}	190	4.35×10^{-5}	170	1.50×10^{-3}	160	4.31×10^{-6}	190

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TABLE 3-8
(Continued)

Receptor Location:	FEMP Production Well (43,75,1)		FEMP Production Well (43,75,5)		SOWC Coll 1 (101,38,1)		SOWC Coll 1 (101,38,5)	
COC	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time
Radionuclides								
Np-237	6.79×10^{-6}	40	7.66×10^{-7}	160	1.48×10^{-8}	870	2.18×10^{-8}	880
Ra-226	6.00×10^{-10}	1000	6.70×10^{-12}	1000	3.50×10^{-32}	1000	3.70×10^{-32}	1000
Sr-90	2.02×10^{-10}	170	9.93×10^{-12}	240	3.73×10^{-15}	420	5.36×10^{-15}	420
Tc-99	3.41×10^{-4}	30	8.10×10^{-5}	30	6.60×10^{-6}	70	9.87×10^{-6}	70
Inorganics								
Antimony	6.68×10^{-2}	0	1.86×10^{-2}	0	5.30×10^{-4}	800	7.99×10^{-4}	850
Arsenic	1.01×10^{-2}	250	9.90×10^{-3}	1000	5.38×10^{-5}	1000	8.60×10^{-5}	1000
Boron	6.83×10^{0}	180	4.90×10^{-1}	630	2.94×10^{-1}	580	4.33×10^{-1}	580
Magnesium	1.06×10^{4}	260	2.07×10^{3}	970	1.81×10^{2}	1000	2.66×10^{2}	1000
Manganese	6.05×10^{1}	800	1.95×10^{2}	0	8.73×10^{-1}	100	1.21×10^{0}	100
Mercury	7.14×10^{-2}	610	1.54×10^{-2}	1000	1.01×10^{-4}	1000	1.44×10^{-4}	1000
Uranium-Total	5.79×10^{0}	0	2.91×10^{0}	30	9.48×10^{-2}	590	1.41×10^{-1}	590
Organics								
Alpha-Chlordane	5.95×10^{-6}	110	1.23×10^{-7}	130	3.60×10^{-5}	220	5.32×10^{-5}	220

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TABLE 3-8
(Continued)

Receptor Location:	SOWC Coll 2		SOWC Coll 2		Strickers Grove Well		N.E. Recept.	
	(108,52,1)		(108,52,5)		(87,44,1)		(90,91,1)	
COC	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time
Radionuclides								
Np-237	8.19×10^{-8}	660	1.14×10^{-7}	670	3.06×10^{-7}	820	1.07×10^{-10}	710
Ra-226	6.80×10^{-30}	1000	1.20×10^{-29}	1000	1.80×10^{-24}	1000	4.50×10^{-35}	1000
Sr-90	1.53×10^{-13}	160	1.82×10^{-13}	160	1.38×10^{-13}	380	3.71×10^{-18}	370
Tc-99	5.58×10^{-5}	70	7.66×10^{-5}	80	1.26×10^{-4}	70	1.23×10^{-4}	60
Inorganics								
Antimony	1.58×10^{-3}	150	2.19×10^{-3}	150	9.90×10^{-3}	900	1.68×10^{-5}	150
Arsenic	8.13×10^{-2}	1000	1.10×10^{-1}	1000	3.32×10^{-4}	1000	2.57×10^{-3}	1000
Boron	5.36×10^{0}	850	7.36×10^{0}	850	6.12×10^{0}	550	3.48×10^{1}	670
Magnesium	1.35×10^{3}	1000	1.85×10^{3}	1000	3.76×10^{3}	1000	4.49×10^{3}	1000
Manganese	5.51×10^{0}	150	8.10×10^{0}	150	2.34×10^{-1}	1000	2.67×10^{-2}	1000
Mercury	9.75×10^{-4}	1000	1.29×10^{-3}	1000	3.93×10^{-3}	1000	2.80×10^{-4}	1000
Uranium-Total	1.73×10^{0}	770	2.33×10^{0}	780	1.85×10^{0}	560	4.45×10^{0}	790
Organics								
Alpha-Chlordane	1.50×10^{-4}	200	2.10×10^{-4}	200	7.21×10^{-4}	210	1.62×10^{-8}	1000

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TABLE H.3-9

GROUNDWATER RECEPTOR CONCENTRATIONS AT TIME OF MAXIMUM CONCENTRATION OF TOTAL URANIUM

Receptor Location:	Well 12	Well 12	Well 13	Well 14	Well 34	Well 2071	Well 2119	Well 2127
(Grid)	(28,46,1)	(28,46,2)	(39,44,1)	(59,38,1)	(5,11,1)	(85,66,1)	(73,52,1)	(5,6,1)
Time (year):	0	0	20	430	0	600	410	0
COC								
Radionuclides (μg/L)								
Np-237	2.180×10^{-6}	1.390×10^{-6}	1.022×10^{-7}	1.837×10^{-6}	4.390×10^{-6}	5.477×10^{-8}	6.939×10^{-7}	6.530×10^{-6}
Ra-226	6.090×10^{-15}	7.510×10^{-16}	4.324×10^{-17}	3.942×10^{-9}	0.00	0.00	7.671×10^{-7}	0.00
Sr-90	0.00	0.00	2.065×10^{-10}	1.180×10^{-10}	0.00	3.911×10^{-14}	4.756×10^{-12}	0.00
Tc-99	2.100×10^{-6}	2.470×10^{-6}	9.850×10^{-4}	3.890×10^{-4}	1.110×10^{-7}	2.460×10^{-5}	1.465×10^{-4}	9.010×10^{-7}
Inorganics (μg/L)								
Antimony	3.430×10^{-3}	4.030×10^{-3}	4.781×10^{-2}	5.874×10^{-2}	8.080×10^{-5}	6.927×10^{-4}	1.079×10^{-2}	4.060×10^{-4}
Arsenic	1.070×10^{0}	5.920×10^{-1}	1.560×10^{-6}	2.082×10^{-3}	7.450×10^{-2}	2.686×10^{-1}	1.265×10^{-2}	1.050×10^{0}
Boron	0.00	0.00	6.300×10^{-1}	2.453×10^{1}	0.00	9.496×10^{0}	1.087×10^{1}	0.00
Magnesium	0.00	0.00	6.690×10^{0}	1.395×10^{4}	0.00	1.052×10^{3}	5.144×10^{3}	0.00
Manganese	2.250×10^{1}	5.050×10^{1}	6.420×10^{1}	3.332×10^{0}	1.660×10^{-10}	6.378×10^{0}	3.367×10^{-1}	1.610×10^{-8}
Mercury	0.00	0.00	2.656×10^{-7}	8.786×10^{-2}	0.00	1.992×10^{-3}	2.461×10^{-3}	0.00
Uranium-Total	1.820×10^{0}	2.740×10^{0}	9.020×10^{0}	7.442×10^{0}	7.920×10^{-2}	5.606×10^{0}	3.998×10^{0}	3.520×10^{-1}
Organics (μg/L)								
Alpha-Chlordane	0.00	0.00	5.192×10^{-4}	2.594×10^{-4}	0.00	6.710×10^{-8}	2.158×10^{-5}	0.00

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TABLE H.3-9
(Continued)

Receptor Location: (Grid)	FEMP Production Well (43,75,1)	FEMP Production Well (43,75,5)	SOWC Coll 1 (101,38,1)	SOWC Coll 1 (101,38,5)	SOWC Coll 2 (108,52,1)	SOWC Coll 2 (108,52,5)	Strickers Grove Well (87,44,1)	NE Recept. (90,91,1)
Time (Years):	0	30	590	590	770	780	560	790
COC								
Radionuclides (μg/L)								
Np-237	5.790×10^{0}	2.592×10^{-8}	4.054×10^{-9}	5.760×10^{-9}	7.000×10^{-8}	9.598×10^{-8}	9.026×10^{-8}	9.868×10^{-11}
Ra-226	0.00	1.393×10^{-17}	0.00	0.00	0.00	0.00	0.00	0.00
Sr-90	0.00	1.185×10^{-14}	3.710×10^{-15}	5.334×10^{-15}	1.894×10^{-14}	2.609×10^{-14}	1.371×10^{-13}	2.358×10^{-18}
Tc-99	2.020×10^{-5}	8.100×10^{-5}	5.399×10^{-6}	8.081×10^{-6}	2.400×10^{-5}	3.338×10^{-5}	1.027×10^{-4}	5.843×10^{-6}
Inorganics (μg/L)								
Antimony	6.680×10^{-2}	1.246×10^{-2}	5.287×10^{-4}	7.969×10^{-4}	1.387×10^{-3}	1.952×10^{-3}	9.884×10^{-3}	8.334×10^{-7}
Arsenic	3.670×10^{-8}	1.590×10^{-9}	1.373×10^{-7}	2.433×10^{-7}	1.354×10^{-2}	2.003×10^{-2}	6.316×10^{-8}	1.139×10^{-4}
Boron	0.00	3.586×10^{-6}	2.930×10^{-1}	4.325×10^{-1}	4.678×10^{0}	6.588×10^{0}	6.097×10^{0}	2.024×10^{1}
Magnesium	0.00	2.475×10^{-5}	1.944×10^{1}	2.768×10^{1}	9.383×10^{2}	1.303×10^{3}	4.198×10^{2}	8.661×10^{2}
Manganese	6.290×10^{-2}	1.793×10^{2}	1.548×10^{-2}	2.219×10^{-2}	1.027×10^{-1}	1.257×10^{-1}	1.815×10^{-2}	3.414×10^{-3}
Mercury	0.00	3.706×10^{-15}	4.550×10^{-7}	6.516×10^{-7}	2.788×10^{-4}	3.703×10^{-4}	1.926×10^{-5}	6.914×10^{-5}
Uranium-Total	5.790×10^{0}	2.910×10^{0}	9.478×10^{-2}	1.409×10^{-1}	1.731×10^{0}	2.325×10^{0}	1.853×10^{0}	4.453×10^{0}
Organics (μg/L)								
Alpha-Chlordane	0.00	4.176×10^{-10}	1.604×10^{-6}	2.440×10^{-6}	1.964×10^{-6}	2.805×10^{-6}	2.929×10^{-5}	5.937×10^{-10}

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- The residual perched groundwater contamination will not significantly impact the Great Miami Aquifer.

- Surface water infiltration through the SSOD and Paddys Run with residual contaminations are the most significant sources of future groundwater contaminations for antimony, mercury, magnesium, Sr-90, and Tc-99.

- Surface water mass loadings of antimony, manganese, and mercury are from surface soil at the background concentration levels.

- Source areas 575a and 575b are the most significant residual contamination sources for Np-237 and magnesium through the vertical migration pathway.

- Groundwater along the northern bedrock boundary of the aquifer does not have a significant simulated flow rate. Therefore, this area could become a local stagnation zone and result in significant accumulated contaminant concentrations with time. The maximum future concentrations of uranium and boron occur in this area due to loading from Source Area 560a. The mass loading rates from this area are relatively small. The significant groundwater concentrations are caused by long-term accumulation of contaminant mass in this small area.

- Residual contamination plumes of arsenic, manganese, and Ra-226 do not migrate significantly and remain relatively localized in the 1000-year period, as shown in Figures H.3-7 through H.3-9.

The results of the conceptual long-term performance evaluation of the on-site disposal cell from Monte Carlo simulations are summarized in Appendix F (Section F.5.5.6). Based on these results, one may conclude that the WAC and WAC application procedure developed and used in the Operable Unit 5 FS generally provide conservative design requirements for the on-site disposal cell. In general, uranium concentrations in the aquifer due to future loading from the disposal cell will be much less than 20 μg/L within the first 500 years, even if the mean performance lifetime of the cap is only 600 years with a relatively high standard deviation of 200 years. With very high certainty, the future impacts from the on-site disposal cell will be insignificant within the first 200 years, regardless of the performance lifetime of the upper clay layer in the multi-layer cap. The future long-term impacts (i.e., within 1000 years) from the on-site disposal cell will very likely be acceptable (i.e., less than 20 μg/L) if the mean performance lifetime of the upper clay layer in the multi-layer cap is longer than 800 years.

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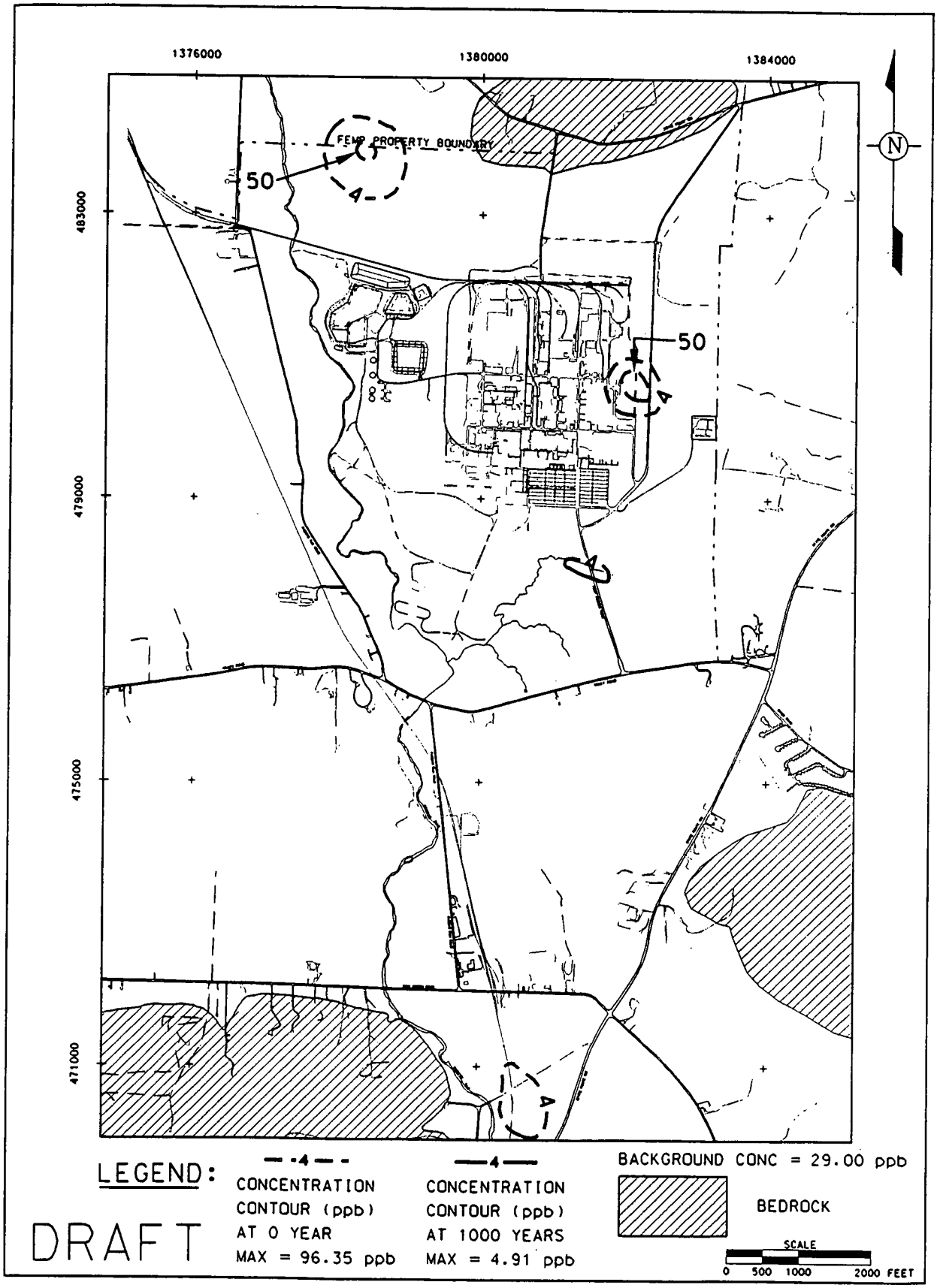

FIGURE H.3-7. ARSENIC CONCENTRATION CONTOURS. MOVEMENT OVER 1000 YEARS FOLLOWING REMEDIAL ACTIONS

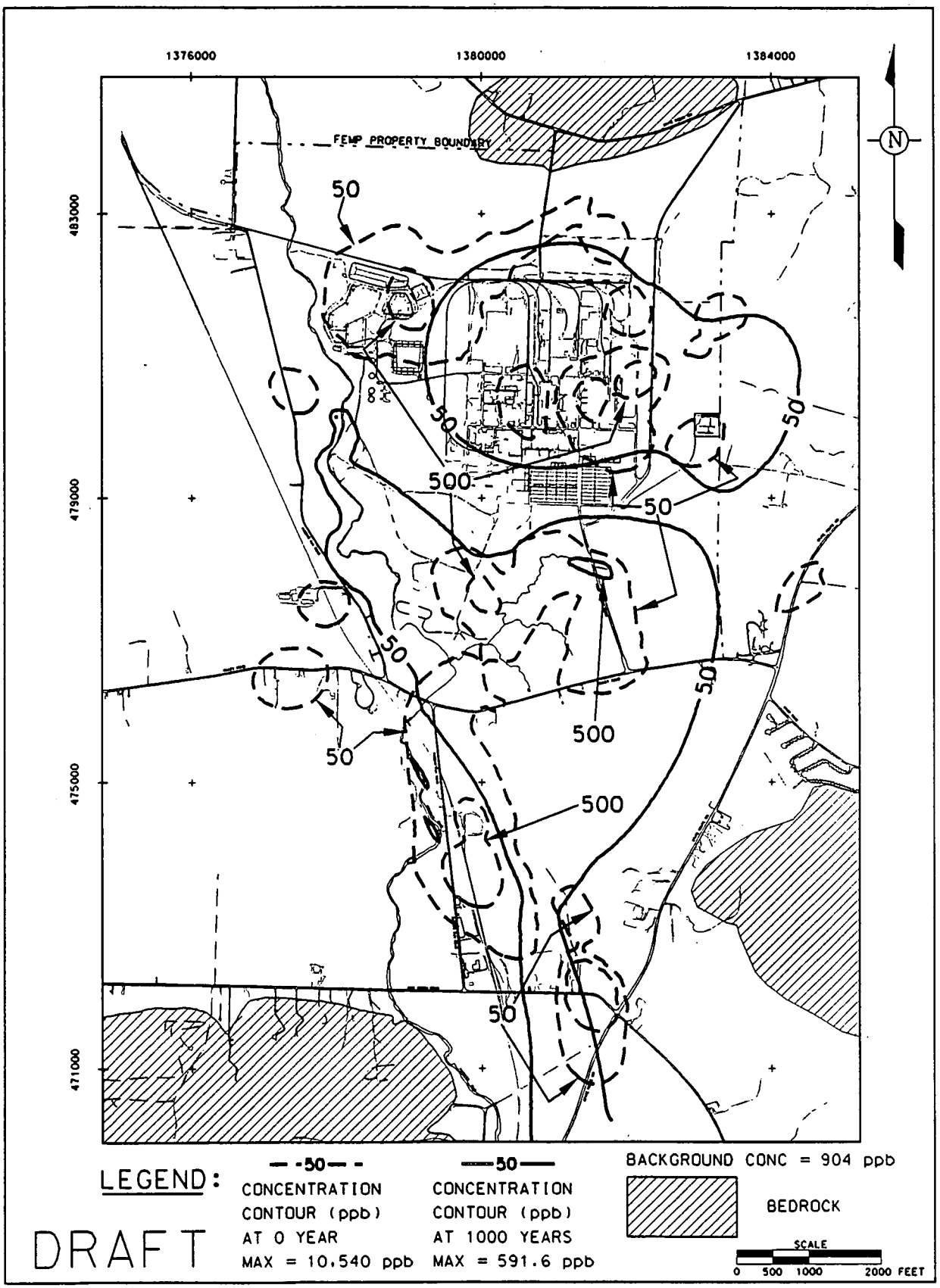

FIGURE H.3-8. MANGANESE CONCENTRATION CONTOURS, MOVEMENT OVER 1000 YEARS FOLLOWING REMEDIAL ACTIONS

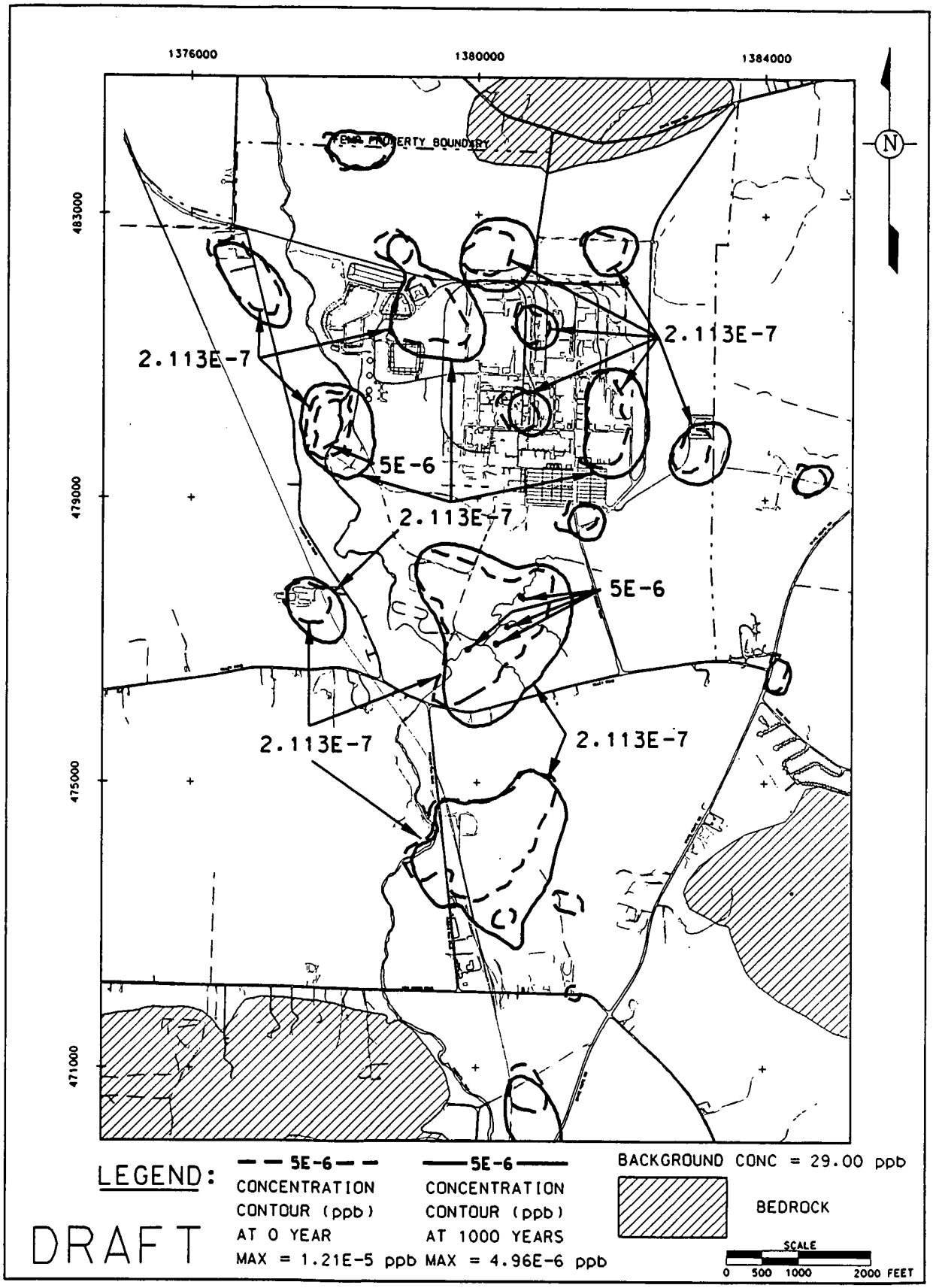

FIGURE H.3-9. Ra-226 CONCENTRATION CONTOURS. MOVEMENT OVER 1000 YEARS FOLLOWING REMEDIAL ACTIONS

H.4.0 RISK CHARACTERIZATION

This section presents the risk characterization methodology and results for the Operable Unit 5 CRARE. The section has been structured to facilitate an understanding of risk quantification. Section H.4.1 discusses the projected exposure model and land-use conditions associated with implementation of the adopted site-wide remedy. Section H.4.2 details the general quantification techniques needed to evaluate chronic incremental exposure via numerous pathways. Section H.4.3 presents a discussion of toxicity associated with exposure to chemicals and radionuclides and the values used in this CRARE. Section H.4.4 details the general quantification techniques used to estimate incremental carcinogenic and noncarcinogenic risk associated with exposure to chemicals and radionuclides. Section H.4.5 presents the results of the previously outlined risk methodology for the target receptors associated with the adopted site-wide remedy and additional reference receptors. The risk results strictly reflect the incremental risks associated with postremedial sources above background (radionuclides and inorganics). Risks associated with postremedial sources including variations of background are presented in Attachment H.V. For specific information regarding the calculation of the incremental risk results, see Attachments H.III and H.IV.

H.4.1 EXPOSURE SCENARIOS FOR SOURCE CONFIGURATION AND LAND USE

To quantify incremental risks associated with the remediated FEMP site, an exposure scenario for source configuration and land use was developed and evaluated. Based on the proposed use of the FEMP site as an undeveloped park for the Operable Unit 5 representative remedial alternative (FS Alternative 3A, Case 7), two types of target receptor were considered, on-property and off-property. The on-property target receptor evaluated is the recreational (undeveloped-park) user, and the off-property target receptors are the off-property resident farmers (adult and child). Additional (reference) receptors representing other land uses were evaluated to provide a comparison of risk, and to show the potential risk in the event that contemplated institutional controls were lost, resulting in an alternate land use of the FEMP. Both target and reference receptors are described in Section H.4.1.3.

Postremedial site conditions (as shown in Figure H.2-1) assumed as part of the adopted site-wide remedy to include a single on-site disposal cell storing waste from several operable units and residual soils within the excavated areas of Operable Unit 5. The PRLs for the site-wide remedy have been set based upon protection of the Great Miami Aquifer to maximum concentration limits (MCLs) (existing and proposed) and protection of the undeveloped-park user and off-property farmers. A conceptual exposure model has been developed for the adopted site-wide remedy and is presented in Figure H.4-1. This exposure model presents the sources of contamination, release mechanisms, exposure media, exposure pathways, and receptors. Each of these components, which contributed to the development and evaluation of the exposure scenario, is described below.

PRIMARY SOURCES	RELEASE MECHANISMS	EXPOSURE MEDIA	EXPOSURE PATHWAYS	TARGET RECEPTORS			REFERENCE RECEPTORS							
				RECREATIONAL USER (UNDEVELOPED PARK)	OFF-PROPERTY ADULT	OFF-PROPERTY CHILD	ON-PROPERTY ADULT	ON-PROPERTY CHILD	MILK AND MEAT CONSUMER	COMMERCIAL/INDUSTRIAL USER	RECREATIONAL USER (DEVELOPED PARK)	RECREATIONAL USER (WILDLIFE RESERVE)	EXPANDED TRESPASSER	GREAT MIAMI RIVER USER
FEMP DISPOSAL CELL		AIR	INHALATION	X	X	X	X	X	1	X	X	X	X	1
			EXTERNAL RADIATION	3	3	3	3	3	1	3	3	3	3	1
		SOIL	EXTERNAL RADIATION	X	X	X	X	X	1	X	X	X	X	1
			INCIDENTAL INGESTION	X	X	X	X	X	1	X	X	X	X	1
			DERMAL CONTACT	X	X	X	X	X	1	X	X	X	X	1
			FOOD	1	X	X	X	X	X	1	1	1	1	1
	VOLATILIZATION/ GASEOUS EMISSIONS	AIR	EXTERNAL RADIATION	3	3	3	3	3	1	3	3	3	3	1
			INHALATION	X	X	X	X	X	2	X	X	X	X	1
	WIND EROSION/ PARTICULATE EMISSIONS		DESPOSITION TO BODY SURFACE	2	2	2	2	2	X	2	2	2	2	1
			DEPOSITION TO CROPS	1	X	X	X	X	X	1	1	1	1	1
RESIDUAL SURFACE SOIL AFTER REMEDIATION		SURFACE WATER	INHALATION/SHOWERING	1	1	1	1	1	1	1	1	1	1	X
			DERMAL CONTACT/SHOWERING	1	1	1	1	1	1	1	1	1	1	X
			INGESTION/WADING	X	1	1	1	1	1	1	X	1	1	X
			INGEST DRINKING WATER	1	1	1	1	1	1	1	1	X	1	X
			DERMAL CONTACT/WADING	X	1	1	1	1	1	1	X	1	1	X
			FOOD	1	2	2	2	2	2	1	1	1	1	X
	SURFACE RUNOFF	SEDIMENT	EXTERNAL RADIATION	X	X	X	X	X	1	X	X	X	X	1
			INCIDENTAL INGESTION	X	X	X	X	X	1	X	X	X	X	1
			DERMAL CONTACT	X	X	X	X	X	1	X	X	X	X	1
			FOOD	1	X	X	X	X	X	1	1	1	1	2
RESIDUAL CONTAMINATED GROUNDWATER AFTER REMEDIATION	LEACHING/INFILTRATION	GROUNDWATER	INHALATION/SHOWERING	1	2	2	2	2	1	1	1	1	1	1
			INGEST DRINKING WATER	1	2	2	2	2	1	1	1	1	1	1
			DERMAL CONTACT/SHOWERING	1	2	2	2	2	1	1	1	1	1	1
			FOOD/IRRIGATED CROPS	1	X	X	X	X	X	1	1	1	1	1

LEGEND:

- ☒ DENOTES A COMPLETE PATHWAY. PATHWAY-SPECIFIC RISK WILL BE QUANTIFIED IN APPENDIX G.
- 1 EXPOSURE ROUTE INCOMPLETE OR NOT APPLICABLE.
- 2 POTENTIAL IMPACT OF THIS EXPOSURE PATHWAY IS INSIGNIFICANT WHEN COMPARED TO THE OTHER EXPOSURE PATHWAYS FOR THE SAME RECEPTOR.
- 3 CERCLA RISK ASSESSMENT METHODS FOR RADIONUCLIDES DO NOT ADDRESS THIS EXPOSURE ROUTE.

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FIGURE H.4-1. CONCEPTUAL EXPOSURE MODEL, ADOPTED SITE-WIDE REMEDY

H.4.1.1 Land-Use Objective Conceptual Model

Figure H.4-1 presents the conceptual exposure model for the adopted site-wide remedy. The model examines the source terms and land uses of the FEMP during the 1000-year period immediately following completion of remedial actions. The land-use objective for Case 7 (Operable Unit 5 representative remedial alternative) has been adopted as the primary objective of the site-wide remedy. The land use objective for off-property areas remains residential farming.

H.4.1.2 Sources, Waste-Release Mechanisms, and Exposure Pathways

COC sources and their potential release mechanisms serve as the primary elements to the exposure pathways. Sources, waste-release mechanisms, and exposure pathways identified for the adopted site-wide remedy are presented in the conceptual exposure model (Figure H.4-1) and are described below.

H.4.1.2.1 COC Sources

After site-wide remediation is complete, it is assumed that all structures will be removed. As shown in Figure H.2-1, Postremedial Site Conditions, the features and COC sources remaining at the FEMP will be:

- Permanent on-site disposal cell
- Residual contamination in soil that meets the PRLs
- Residual contamination of the Great Miami Aquifer

As depicted in the exposure model, the sources of residual COCs after remediation is complete may include:

- Remediated areas backfilled with clean treated soil
- Soil left undisturbed because it is at or below the target PRLs
- Leachate from the on-site disposal cell
- External radiation released from the disposal cell or residual soils
- Residual contamination in the groundwater after remediation

This conceptual exposure model addresses the sources of residual COCs that can migrate to other environmental media or serve as a direct source of exposure to receptors.

H.4.1.2.2 Waste-Release Mechanisms

Release mechanisms identified for the adopted site-wide remedy land-use objective include volatilization and gaseous emissions, wind erosion and particulate emissions, surface runoff, leaching, and infiltration to the underlying groundwater.

Volatilization and Gaseous Emission - Gaseous COCs may be released through volatilization or radioactive decay (e.g., radon). Transport through air is expected to be a major pathway for COCs in residual soil remaining after remediation.

Wind Erosion and Particulate Emissions - Release of particulates to the air pathway may occur through the generation of particulates by wind or surface soil disturbance.

Surface Runoff - COCs in the surface soil can impact surface water/sediment through runoff. Runoff can transport COCs to receiving surface water bodies where receptors may come in direct contact by wading or showering, or indirect contact by irrigation of crops. Surface water transports contaminants by conveying dissolved and suspended solids to receptors as it flows across the ground surface and along any drainage features. It is assumed that no surface water or sediment runoff would occur from the disposal cell due to the presence of an engineered multi-layered capping system.

Leaching and Infiltration - The FEMP site has a humid climate with an average annual rainfall of about 40 inches (102 centimeters). A portion of this water percolates through subsurface soil and recharges the underlying aquifer. Percolation can also occur, however, to a much reduced degree through the disposal cell. COCs in the waste and soil in the disposal cell can be transported vertically with this flow. However, degradation, retardation, and radioactive decay have the ability to modify the concentrations that eventually reach the aquifer. Dilution of constituents can also occur in the groundwater. Eventually, the contaminant completes the pathway by transport to a source of groundwater such as a well which can be accessed by a receptor for residential and agricultural use.

H.4.1.2.3 Exposure Pathways

The media impacted by the various release mechanisms include air, soil, sediment, surface water, and groundwater. Contaminated material within the various media can travel through several exposure pathways to which potential receptors may be exposed. An exposure pathway describes the course a COC takes from its source to an exposed individual and how the COC enters and affects the human body. An exposure pathway links the source, release mechanism, locations, and activity patterns to quantify the impact of COCs on hypothetical human receptors.

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There are numerous potential exposure pathways at the FEMP by which receptors can come in contact with COCs. These pathways inhalation, incidental ingestion, dermal contact, and external radiation. On the right-hand side of the exposure model (Figure H.4-1), the various combinations of exposure pathways and media are tabulated. Each pathway and medium is reviewed for applicability/ significance for each of the exposed receptors. Pathways identified as being complete and significant are denoted with an "X," while those not expected to result in significant exposures for a given receptor are noted, along with an explanation of why these pathways were not included in the quantitative risk analysis in the CRARE. The exposure pathways are described below.

Inhalation - A receptor's exposure through this pathway begins with COCs being transported from their source by air, eventually reaching the receptor through inhalation. The applicability of the inhalation pathway depends on the different characteristics of the receptor's daily activities. The significant exposures from this pathway are through the inhalation of gases, including radon, and resuspended particulates.

Ingestion - Direct ingestion of soil, sediment, drinking water, and food are considered significant pathways for many receptors. Ingestion of contaminated substances can come from direct or indirect routes. For example, a receptor may ingest COCs in drinking water from the aquifer, through incidental ingestion while wading in contaminated surface water, or by ingesting vegetation irrigated with contaminated water.

Consumption of meat or milk from animals ingesting contaminated soil, water, or foliage while grazing on FEMP property is considered in this risk analysis. Exposure pathways such as ingestion of contaminated soil, surface water, sediment, groundwater, and crops are significant for the receptors evaluated in this risk assessment.

Dermal Contact - This pathway encompasses all of the receptor's activities that result in direct contact with contaminated soil, sediment, surface water, or groundwater.

External Radiation - Exposure routes are divided into internal and external exposures. Internal exposures occur when COCs are introduced directly into the human body through inhalation, ingestion, or absorption across dermal surfaces. External exposures do not require physical contact and occur when a receptor is in proximity to radioactive material. External exposures are only calculated for gamma emitting radionuclides and result in the irradiation of the exposed individual. This pathway may be significant for receptors in close proximity to residual soil or waste (e.g., on-property receptors). Significant external radiation pathways identified for several of the evaluated receptors include exposure to radiation originating from contaminated soil or sediment.

H.4.1.3 Receptors

Both on- and off-property receptors were evaluated in this CRARE. Three target receptors were selected because they are considered RME receptors for the land use specified by the Operable Unit 5 representative remedial alternative (i.e., an undeveloped park). The on-property target receptor is the undeveloped-park user, while the off-property target receptors are the resident farmers (adult and child). The undeveloped-park user is assumed to make use of the entire FEMP site. The off-property residents are assumed to reside outside the existing eastern boundary of the FEMP.

The conceptual exposure model (Figure H.4-1) presents an additional eight receptors. On-property receptors were developed for land uses such as residential/agricultural, commercial/industrial, and recreational (park) use. On-property farmers were evaluated for residential and agricultural uses of the FEMP. A commercial/industrial receptor was evaluated for potential exposures to a worker maintaining the portion of the FEMP site that is restricted and retained for federal ownership (i.e., disposal cell area). Additionally, an expanded trespasser receptor was evaluated in the event an intruder trespasses onto the restricted portion of the FEMP site (i.e., disposal cell area). These receptor scenarios evaluated for the adopted site-wide remedy are for comparison purposes only.

This CRARE focuses on the target receptors (i.e., undeveloped-park user and off-property residents) for the Operable Unit 5 representative remedial alternative. The remaining receptors are "reference" receptors presented for comparison purposes. The reference receptors would be applicable in the unlikely case that the FEMP lost institutional controls, resulting in alternative land uses.

H.4.1.3.1 Target Receptors

Undeveloped-Park User - The undeveloped-park user was selected to evaluate the potential risk to human receptors if portions of the site were released for use as a neighborhood park with limited facilities. Under this scenario, there would be no restrooms or developed recreational facilities with the exception of walking trails, open spaces of grassy fields, picnic tables, and benches. The activities for this scenario include ball playing, picnicking, dirt-bike riding, bird watching, and wildlife viewing. Because the environmental setting is assumed to be more intensively developed (i.e., a neighborhood park) versus rural (i.e., a wildlife reserve), this scenario is assumed to have a greater access potential for youth. Also, the presence of open spaces for playing ball and the types of recreation offered by this scenario are assumed to be more attractive to youths and less attractive to adults.

Because there are no restroom facilities provided at the undeveloped park, it is assumed that the average use of the park and the exposure time per day will be reduced from the developed-park user. Activities such as dirt-bike riding are assumed to increase possible fugitive dust emissions in specific areas (i.e., in the vicinity of biking trails where this activity is occurring).

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Exposure pathways for this receptor would include inhalation of gases, vapors, and dust; ingestion of, dermal contact with, and external radiation from residual contaminated soil and sediment; and ingestion of and dermal contact with surface water while wading. There would be no exposures to residual contaminants in the Great Miami Aquifer or perched water zones.

Off-Property Resident Farm Adult - The inclusion of a farmer, assumed to live immediately adjacent to the existing FEMP property boundary, was determined to be highly likely based on current conditions and has therefore been included as a target receptor in this risk analysis. The major concern for this receptor is the exposure received from regular use of water from the Great Miami Aquifer for both residential and agricultural uses. This farmer could also be exposed to COCs from site residual contaminants carried by the wind as gases, vapors, and particulates. This receptor would be exposed to on-property residual soil through dermal contact or external radiation since off-property soils have received contaminants as a result of disposition.

Exposure pathways for this receptor would include: inhalation of gases, vapors, and dust; ingestion of food products affected by residual contaminated dust from the site; ingestion of, dermal contact with, and external radiation from residual contaminated soil; inhalation and dermal contact with contaminated water from the Great Miami Aquifer while showering; ingestion of contaminated groundwater while drinking; and consumption of food products (e.g., produce, dairy products, and meat) irrigated with contaminated groundwater.

Off-Property Resident Farm Child - The child (ages 1 through 6) living off-property, adjacent to the FEMP, is evaluated as a subpopulation of concern because this receptor is more sensitive to exposure than adults. For this reason, this receptor has been evaluated in this risk analysis. A young child residing adjacent to the FEMP is assumed to be exposed through the same pathways as the adult off-property farmer.

H.4.1.3.2 Reference Receptors

On-Property Resident Farm Adult - If the FEMP lost all institutional controls contemplated by the adopted site-wide remedy, the site could potentially revert to residential and agricultural uses in the future, and an adult farmer could reside on the site after remediation. Potential exposures to this receptor may result from direct contact with residual contaminated soil and groundwater.

Exposure pathways for this receptor would include: inhalation of gases, vapors, and dust; ingestion of food products affected by residual contaminated dust from the site; ingestion of, dermal contact with, and external radiation from residual contaminated soil; inhalation and dermal contact with contaminated water from the Great Miami Aquifer while showering; ingestion of contaminated groundwater while drinking; and consumption of food products (e.g., produce, dairy products, and

meat) irrigated with contaminated groundwater. These pathways assume the on-property farmer (adult) would reside on the remediated FEMP and would be growing produce, tending livestock, and performing general farming activities.

On-Property Resident Farm Child - The child (ages 1 through 6) living on the property would form a subpopulation of concern because they may be more sensitive to exposure than adults. A young child residing on the remediated FEMP is assumed to be exposed through the same pathways as the adult on-property farmer.

Commercial/Industrial User - A worker could be present on the property conducting groundskeeper and maintenance activities throughout the FEMP (not just for Operable Unit 5). Exposure pathways would include: inhalation of fugitive dusts, organics, and gases; and dermal contact with, incidental ingestion of, and external radiation from residual contaminated soil while on the site.

Developed-Park User - This receptor would be used to evaluate the potential residual risks to human receptors if all or portions of the site were released for a neighborhood park which included developed recreational facilities. Under this scenario, restrooms would be available as well as developed recreational facilities such as playgrounds, ball fields for organized sports teams, and picnic facilities. In combination, these developments are assumed to attract more visitors and encourage greater family use of the remediated FEMP site. The activities for this scenario are assumed to result in greater use of the site by children. In addition, the availability of restroom facilities would encourage a longer average use per day per person. The development of ball fields and playgrounds is assumed to result in larger areas of exposed (nonvegetated) soil. The primary effect of exposing areas of bare soil, especially on baseball fields, would be to increase particulate resuspension from wind erosion.

Exposure pathways examined for this receptor are the same as those examined for the undeveloped-park user presented above.

Wildlife-Reserve User - This receptor would be used to evaluate the potential residual risk to human receptors if all or portions of the site were released for use as a wildlife reserve. Under this scenario, there would be no restroom facilities and no developed recreational facilities with the possible exception of hiking or walking trails. Activities would include hiking, bird watching, and viewing other wildlife. An area would be included for adults to walk their pets. The intent of this environmental site setting would be to minimize disturbance of wildlife species. Activities such as hiking and wildlife viewing in a natural setting would be done primarily by older teenage children (age 13 to 18) and adults. Because there would be no restroom facilities or developed playgrounds or

ball parks, the type of recreation offered by this scenario is assumed to be less attractive for a young child, adolescent (age 7 to 12), or senior adults.

The contact rate would be determined based on the age of the receptor, activities, and the exposure time. Because there are no restroom facilities, the average exposure time of 1 hour a day was assumed for young children and senior adults, and 2 hours a day was assumed for the youth and adult. Because the activities associated with this scenario are limited to passive recreation, the air particulate concentrations are assumed equal to modeled ambient levels occurring as a result of wind erosion, assuming a reasonable vegetation cover of 85 percent.

Exposure pathways examined for this receptor would include: inhalation of gases, vapors, and dust; ingestion of, dermal contact with, and external radiation from residual contaminated soil and sediment; and ingestion of and dermal contact with surface water while wading.

Expanded Trespasser - The expanded trespasser is a composite adult/child who illegally uses the restricted portion of the site for recreational purposes. This hypothetical individual would visit the site despite continued federal institutional controls. No specific location would be assigned as the expanded trespasser may wander over the entire FEMP site, except for the on-site disposal cell. Exposure pathways for the expanded trespasser would include: inhalation of fugitive dusts, volatile organics, and gases; dermal contact with, incidental ingestion of, and external radiation from site soil and sediment; and incidental ingestion of and dermal contact with surface water.

Great Miami River User - The Great Miami River user was included to evaluate the exposures incurred during the activities of a receptor who frequently uses the Great Miami River for recreational purposes. The activities of this receptor may include swimming, boating, etc,.

The risk from pathways for this receptor was evaluated for special cases in which an RME was not considered to be exposed, but could be used as an add-on element to risk. For example, any of the RME receptors could also be users of the Great Miami River and, therefore, risk from this pathway can be additive to receptor risk.

Exposure pathways for this receptor include ingestion and dermal contact with surface water from the FEMP that has drained into the Great Miami River. Additional uses of the Great Miami River include household and agricultural. Under these uses, a receptor could be exposed through ingestion of and dermal contact with water from the river. The agricultural user is exposed through ingestion of food products irrigated with water from the river.

Meat and Milk Consumer - This receptor was evaluated to assess the hazards and risks associated with the use of animal products produced by cattle grazing on the remediated FEMP site. Exposure pathways for this receptor include: ingestion of dairy and meat products from cattle grazing, crops affected by dust from the site, and groundwater from the Great Miami River.

As with the Great Miami River user, RME receptors (not including on- and off-property farmers) could also be consumers of animal products produced from cattle grazing on the FEMP site. This pathway can be additive to risk for these receptors.

H.4.2 INTAKE QUANTIFICATION

Exposure is defined as the contact of an organism with a chemical or physical agent. Exposure can occur through multiple pathways, including inhalation, dermal contact, and incidental ingestion resulting from of the contaminant being taken into the body. The amount of contaminant acquired is referred to as the contaminant intake. The fraction of the contaminant absorbed into the body (across the membranes of the gastrointestinal or respiratory system, or through the skin after dermal contact) is referred to as the dose or the absorbed dose of contaminant. This section describes the quantification of these intakes or doses. The general quantitative methodologies employed on the various types of contaminants are presented here. A detailed discussion of equations and parameters used in the quantification of exposures for the 11 RME receptors are consistent with those used in the Operable Unit 5 baseline risk assessment and are presented in Attachment H.III.

In evaluating cancer risks and the potential for adverse noncarcinogenic health effects, it was necessary to estimate contaminant intake for the exposed receptor. For both carcinogenic and noncarcinogenic risk determination, average long-term daily intakes were used to estimate risk. The chronic daily intake (CDI) for hazardous chemical contaminants was estimated based on the following:

$$CDI = C \times CR \times EFD/BW \times 1/AT \qquad \text{(H.4-1)}$$

where

CDI	=	chronic daily intake (mg/kg body weight/d),
C	=	chemical concentration in exposure medium (mg/L),
CR	=	contact rate with exposure medium (L/d),
EFD	=	exposure frequency and duration (d/y, years),
BW	=	body weight (kg), and
AT	=	average time, e.g., the period over which exposure is averaged (days).

In the case of cancer risk assessment, the average lifetime daily intake was used to estimate the ILCR, and AT equalled a full 70-year lifespan. For noncarcinogenic risk assessment, intake was evaluated over the period during which exposures occur, and AT equalled the duration of exposure. In the case

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of dermal exposures, time-weighted absorbed doses were calculated rather than intakes. Otherwise, time-weighted average doses were calculated in the same manner as the contaminant intakes described above.

The equations used to calculate the intake of radioactive material by ingestion or inhalation were adapted from RAGS (EPA 1989a). The intake equations follow.

Inhalation:

$$CDI\ (pCi) = C \times IR \times ED \times EF \times ET \qquad (H.4\text{-}2)$$

Ingestion of soils, liquids, and products:

$$CDI\ (pCi) = C \times IR \times ED \times EF \times FI \qquad (H.4\text{-}3)$$

where

C = concentration of contaminant in exposure media (pCi/m^3, pCi/mg, pCi/kg, or pCi/L),
IR = inhalation or ingestion rate of media (m^3/d, mg/d, kg/d, or L/d),
ET = exposure time (h/d)
EF = exposure frequency (d/y),
ED = exposure duration (y), and
FI = fractional intake (unitless)

The exposure pathways evaluated for each receptor are discussed in Section H.4.1. The exposure point concentrations used for this CRARE are presented in Attachment H.III. The exposure parameters and factors used are summarized in Attachment H.III. The exposure parameters were based on those used in the draft Operable Unit 5 RI report. Specifically, the receptor intakes of COCs were quantified using the methods, models, and parameters specified in the RAWPA (DOE 1992a), the Supplemental Guidance to the RAWPA (DOE 1994g), and the SWCR (DOE 1993a) with the following exceptions.

The soil ingestion rate adopted for the commercial/industrial was 100 mg/day, consistent with the value used in the Operable Unit 4 RI report.

The soil ingestion rate for the RME adult farmer is a site-specific, time-weighted average value based on specific activities performed during the course of the receptor's lifetime and the relative length of time spent in each activity. The first six years of this receptor's life are spent as a young child ingesting 0.2 g/day for 350 days/year (a total of 420 grams). Between 18 and 70 years of age, the RME farmer is assumed to spend 50 years working a farm. Assuming the farmer follows the usual and recommended agricultural practices in Hamilton County, he will spend 100 days/year outdoors working the land, during which he is assumed to consume 0.48 g/day of soil (a total of 2400 grams).

During the remaining 250 days a year spent on the property, the resident farmer ingests soil at a rate of 0.1 g/day, adding another 1250 grams of soil to the farmer's intake during this 50 years. During the remaining 14 years (12 years as an older child and 2 years as an adult), it is assumed that the soil ingestion rate is 0.1 g/day for each of the 350 days/year spent on site (a total of 490 grams). The total soil ingestion, 4560 grams, divided by 25,550 days (365 days x 70 years) yields a time-weighted average intake of 0.18 g/day (180 mg/day).

H.4.3 TOXICITY ASSESSMENT

Two human-health effects are addressed in the toxicity assessment for Operable Unit 5: carcinogenic risks and noncarcinogenic hazards. Carcinogenic risks may be caused by exposure to a chemical carcinogen or ionizing radiation from a radionuclide. The effects of carcinogenic exposure include tumors, sarcomas, and cancer. Potential noncarcinogenic effects of contaminants are numerous and range from kidney or liver damage to localized effects such as skin or eye irritation.

Carcinogenic risk is quantified by the ILCR and is expressed in terms of the probability that a given receptor will develop cancer as a result of estimated exposures. For example, if the receptor has an additional risk of 1 in 10,000 of developing cancer due to these exposures, the probability is expressed as 10^{-4} (1/10,000) risk. A chemical intake calculated in the exposure assessment is multiplied by the specific cancer slope factors (CSF) developed by EPA to determine the ILCR for any given constituent.

In the evaluation of potential exposures for the noncarcinogenic hazards, it was assumed that a dose threshold exists for a given constituent below which no toxic effect will occur. This threshold is used to develop an acceptable intake level, known as a reference dose (RfD). To estimate the noncarcinogenic health hazard, the estimated intake (calculated from the exposure assessment) was divided by the acceptable intake. This ratio is called the hazard quotient (HQ). When HQs for multiple COCs are summed for a particular pathway, the resultant value is the HI. If the ratio of estimated intake to the acceptable intake is greater than 1, the site-related intake is considered to increase the risk of noncarcinogenic toxic effects.

Toxicity profiles for Operable Unit 5 COCs can be found in Appendix A of the RI report (DOE 1994f). The most recent versions of the data from the Integrated Risk Information System (IRIS) database (EPA 1994a) and Health Effects Assessment Summary Tables (HEAST EPA 1994b) were used to obtain CSF and RfD values. Those values used to quantify risk in this CRARE are presented in Section C.4.

The following are exceptions, where information from one chemical was used to model a compound class:

- The carcinogenicity of all polychlorinated biphenyl (PCB) isomers is assumed to be equal to the carcinogenicity of Aroclor-1260 because dose-response data for the other isomers are inconclusive.
- The carcinogenicity of dioxins and furans are determined using EPA's revised 1989 Toxicity Equivalency Factors (TEFs) (EPA 1990d). The TEFs were determined with the basic assumption that all dioxins and furans are carcinogenic.
- The carcinogenicity of polycyclic aromatic hydrocarbons (PAHs) is determined initially using the benzo(a)pyrene cancer slope factors and refined using a relative potency approach (Clement 1988, 1990).

For risk assessment purposes, mixtures of chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs) can be evaluated using EPA's toxicity equivalency method. This approach, based on available toxicological data, uses derived TEFs to convert the concentration of CDD or CDF congeners into an equivalent concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). Table H.4-1 presents the TEFs for a variety of CDD and CDF congeners. Congeners containing chlorines at the 2,3,7, and 8 positions are considered to be more toxic, and congeners without chlorines at those positions are assigned a TEF of "0." However, to be more conservative, all unspecified congeners are assumed to be the more toxic form.

Carcinogenic risk associated with PAHs are determined by applying the relative potency approach described by Clement (1988 and 1990). This approach, approved by EPA Region V, considers the relative potency of the individual PAHs and allows site-specific PAH concentrations to be expressed as relative benzo(a)pyrene concentrations in the risk assessment. The relative potency factors for PAHs are presented in Table H.4-2.

H.4.4 RISK CHARACTERIZATION METHODOLOGY

In this CRARE, the potential risks to humans following exposure to postremediation residual COCs (radionuclides and nonradioactive chemicals) have been estimated using methods established by the EPA. The EPA has provided guidance documents and databases for characterizing human health risk, and these have been used as major sources in preparing CRARE risk assessments:

- Risk Assessment Guidance for Superfund (EPA 1989a and 1991a)
- Integrated Risk Information System (EPA 1994a)
- Health Effects Assessment Summary Tables (EPA 1994b)
- Exposure Factors Handbook (EPA 1989d)

H.4.4.1 Hazardous Chemical Exposures

Risks from nonradionuclide COCs have been estimated for carcinogenic and/or noncarcinogenic effects. Some carcinogens may also pose a noncarcinogenic toxic hazard. For those COCs that have an RfD available, the noncarcinogenic HQ was calculated. Effects due to exposures from these chemicals have been characterized for both types of health effects.

TABLE H.4-1

DIOXIN AND FURAN TOXICITY EQUIVALENCY FACTORS[a]

Compound	TEF
Dioxins	
Mono-, Di-, and Trichlorodibenzo-p-dioxins	0
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1
Other TCDDs	0
2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	0.5
Other PeCDDs	0
2,3,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	0.1
Other HxCDDs	0
2,3,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	0.01
Other HpCDDs	0
Octachlorodibenzo-p-dioxin (OCDD)	0.001
Furans	
Mono-, Di-, Trichlorodibenzo-p-furans	0
2,3,7,8-Tetrachlorodibenzo-p-furan (TCDF)	0.1
Other TCDFs	0
1,2,3,7,8-Pentachlorodibenzo-p-furan (PeCDF)	0.05
2,3,4,7,8-Pentachlorodibenzo-p-furan (PeCDF)	0.5
Other PeCDFs	0
2,3,7,8-Hexachlorodibenzo-p-furan (HxCDF)	0.1
Other HxCDFs	0
2,3,7,8-Heptachlorodibenzo-p-furan (HpCDF)	0.01
Other HpCDFs	0
Octachlorodibenzo-p-furan (OCDF)	0.001

[a] U.S. EPA, 1989, "Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans (CDDs and CDFs) and 1989 Update," PB90-145756.

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TABLE H.4-2

TOXICITY EQUIVALENCY FACTORS (TEFs) AND CORRESPONDING ORAL AND INHALATION SLOPE FACTORS FOR THE GROUP B2 PAHs[a]

PAH	Relative Potency	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Slope Factor $(mg/kg\text{-}day)^{-1}$
Benzo(a)pyrene	1.0	7.3	6.1
Benzo(a)anthracene	0.1	0.73	0.61
Benzo(b)fluoranthene	0.1	0.73	0.61
Benzo(k)fluoranthene	0.01	0.073	0.061
Chrysene	0.001	0.0073	0.0061
Dibenzo(a,h)anthracene	1.0	7.3	6.1
Indeno(1,2,3-cd)pyrene	0.1	0.73	0.61

[a]U.S. EPA, 1993, Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons, EPA/600/R-93/089, EPA Washington, D.C.

Risk Characterization Methodology for Carcinogens

The risk attributed to a carcinogen was estimated as the ILCR of an individual as a result of exposure to the substance. At low doses, the risk of developing cancer was estimated as follows (EPA 1989a):

$$Risk = (CDI)(SF) \qquad \text{(H.4-4)}$$

where

Risk = risk of cancer incidence, expressed as a unitless probability,
CDI = chronic daily intake averaged over 70 years (mg/kg/day), and
SF = slope factor $(mg/kg/day)^{-1}$.

For dermal exposure, cancer risks were calculated using adjusted toxicity factors based on absorbed doses of contaminants rather than contaminant intakes. For a given pathway with simultaneous exposure of a receptor to several carcinogens, the following equation was used to sum cancer risks:

$$Risk_p = Risk\ (chem_1) + Risk\ (chem_2) + \ldots Risk\ (chem_i) \qquad \text{(H.4-5)}$$

where

$Risk_p$ = total pathway risk of cancer incidence and
$Risk\ (chem_i)$ = risk associated with an individual carcinogenic chemical.

In compliance with EPA guidance (EPA 1989a), the ILCR values estimated in this CRARE for the potentially exposed receptor were compared to an incremental upper-bound lifetime cancer risk of 10^{-4} to 10^{-6}.

Risk Characterization Methodology for Noncarcinogens

The risk associated with exposure to noncarcinogenic hazardous COCs was evaluated by comparing an exposure level or intake to an RfD. It is recognized that this methodology for assessing the human health effect for noncarcinogens does not give a measure of risk as is calculated for the carcinogens. Even so, for convenience, the term "risk" will continue to be used when discussing these evaluations. The ratio of intake/RfD for a single contaminant is the HQ and is defined as (EPA 1989a):

$$HQ = I/RfD \qquad \text{(H.4-6)}$$

where

HQ	=	hazard quotient (unitless),
I	=	intake of a chemical (mg/kg/day), and
RfD	=	reference dose (mg/kg/day).

When using this equation to estimate potential noncarcinogenic risk, the intake and RfD must be for exposures of equivalent duration (e.g., subchronic, chronic, or fewer than two weeks). For this CRARE, COC exposures have been evaluated in all cases on a chronic basis, using chronic RfD values. Analogous to cancer risks, dermal noncancer risks were assessed using absorbed dose rather than intake.

In the case of simultaneous exposure of a receptor to several chemicals, an HI was calculated as the sum of the HQs by:

$$HI = I_i/RfD_1 + I_2/RfD_2 + \ldots I_i/RfD_i \qquad \text{(H.4-7)}$$

where

HI	=	hazard index (unitless),
I_i	=	intake for the ith toxicant, and
RfD_i	=	reference dose for the ith toxicant.

An HI is an indicator of the potential for adverse effects associated with chronic exposures to multiple chemicals. In effect, HIs assume dose additivity for all COCs (EPA 1989a).

In compliance with EPA guidance (EPA 1989a), the noncarcinogenic HIs summed across pathways were compared to "unity." An HI of unity indicates that the exposure intake is equal to the RfD. If the HI is greater than 1 or "above unity," there is concern for potential health effects. Major

categories of noncarcinogenic health effects include neurotoxicity, developmental toxicity, reproductive toxicity, immunotoxicity, and adverse effects on target organ, such as hepatic, renal, respiratory, cardiovascular, and dermal/ocular problems (EPA 1989a).

H.4.4.2 Radiological Exposures

The procedures for estimating the total lifetime excess cancer risks due to exposure to radionuclides are described in this section.

Risk Characterization Methodology for Internal Exposures

Risk characterization for internal exposures to radionuclides (intake via inhalation or ingestion) was calculated as follows (EPA 1989a):

$$\text{Risk} = (I)(SF) \qquad \text{(H.4-8)}$$

where

Risk = risk of cancer incidence, expressed as a unitless probability,
I = lifetime radionuclide intake (pCi), and
SF = slope factor $(pCi)^{-1}$.

The slope factor is either a HEAST value for a particular radionuclide or the sum of the HEAST slope factors for that radionuclide and its short-lived progeny to account for ingrowth during storage and/or environmental transport.

Risk Characterization Methodology for External Gamma Exposures

For this CRARE, risk characterization for external exposure to gamma-emitting radionuclides in contaminated surface soil was calculated as follows (DOE 1992a):

$$\text{Risk} = (SF)[(C_s)(EF)(ED)(ET)(1 - SH)] \qquad \text{(H.4-9)}$$

where

Risk = risk of cancer incidence, expressed as a unitless probability,
C_s = radionuclide soil concentration (pCi/g),
SF = radionuclide slope factor (risk/yr/pCi/g) from EPA (1994a),
ET = fraction of day exposed (unitless),
ED = exposure duration (years),
EF = modifying factor, fraction of year exposed (unitless), and
SH = shielding factor (unitless).

External slope factors do not include contributions from decay products (radioactive progeny). In some cases, these contributions were substantial and required the inclusion of progeny in the overall risk calculation.

H.4.5 ILCR Residual Human Health Risks

This section presents summaries of the ILCR and HI as calculated for each of the target and reference receptors. Complete calculation sheets can be found in Attachment H.IV. All risks in this section were calculated using the method set out by CRARE Option where the background concentrations of radionuclides and inorganics were subtracted for residual source term concentrations.

H.4.5.1 Target Receptors

The following paragraphs present a summary of risk analyses for the RME individual under the adopted site-wide remedy. These receptors and corresponding risks represent a conservative estimate in accordance with the use of the FEMP as an undeveloped park.

Undeveloped-Park User

The undeveloped-park user represents the projected postremedial site user under the adopted site-wide remedial alternative. The carcinogenic (ILCR) and noncarcinogenic (HI) risks associated with the undeveloped-park user are presented in Table H.4-3.

The total HI for this receptor (1.0×10^{-2}) is primarily due to dermal contact with soils (8.2×10^{-3}) and is below the benchmark of 1.0. The principal contributor is uranium (6.6×10^{-3}).

The total ILCR for the undeveloped-park user (2.2×10^{-6}) is a result of direct radiation exposure (1.8×10^{-6}) and is within the risk range of 10^{-6}. Radium (1.5×10^{-6}) is the primary contributor.

Off-Property Resident Farm Adult

Projected future land use assumes continued farming adjacent to the FEMP. The off-property resident farm adult represents the most conservative off-property receptor for carcinogenic evaluation.

The risk results for this receptor are presented in Table H.4-4. The total HI for this receptor is 1.6×10^{-1}, well below the benchmark of 1.0.

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TABLE H.4-3

SUMMARY OF POTENTIAL HEALTH EFFECTS: UNDEVELOPED-PARK USER[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	NA[c]
Incidental ingestion of residual soils (chemicals)	1.6×10^{-4}
Dermal contact with residual soils (chemicals)	8.2×10^{-3}
Ingestion of meat (chemicals)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of drinking water (chemicals)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	5.7×10^{-4}
Dermal contact while wading (chemicals)	1.6×10^{-3}
RME Individual HI =	1.0×10^{-2}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	6.5×10^{-12}
Inhalation of particulates (radionuclides)	7.3×10^{-9}
Incidental ingestion of residual soils (chemicals)	3.2×10^{-8}
Incidental ingestion of residual soils (radionuclides)	1.5×10^{-14}
Dermal contact with residual soils (chemicals)	2.2×10^{-7}
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	NA
Incidental ingestion while wading (chemicals)	4.2×10^{-8}
Dermal contact while wading (chemicals)	6.4×10^{-8}
Incidental ingestion while wading (radionuclides)	9.6×10^{-10}
Ingestion of meat (chemicals)	NA
Ingestion of meat (radionuclides)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of dairy products (radionuclides)	NA
Ingestion of vegetables and fruit (Chemicals)	NA
Ingestion of vegetables and fruit (radionuclides)	NA
Direct radiation	1.8×10^{-6}
RME Individual Total Risk =	2.2×10^{-6}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

The estimated total ILCR (4.3×10^{-5}) is within the target risk range (10^{-4} to 10^{-6}). The principal contributors are the risks due to ingestion of dairy products, 1.3×10^{-5} for chemicals and 1.2×10^{-5} for radionuclides. The primary drivers are Aroclor-1254 and benzo(a)pyrene for chemicals and technetium for radionuclides.

Off-Property Resident Farm Child

The off-property resident farm child represents the most conservative off-property receptor for noncarcinogenic risk evaluation under the adopted site-wide remedy land-use conditions.

The total HI for this receptor (7.2×10^{-1}) is below the benchmark of 1.0 primarily due to the ingestion of dairy products (2.7×10^{-1}), ingestion of vegetables (1.6×10^{-1}), dermal contact while bathing (1.3×10^{-1}), and drinking water ingestion (1.1×10^{-1}), as shown in Table H.4-5. The principal contributors are uranium and magnesium.

A total ILCR of 1.7×10^{-5} is predicted for this receptor, with ingestion of dairy products (1.4×10^{-5}) and ingestion of vegetable products (1.6×10^{-6}) contributing more than 90 percent of the total (Table H.4-5). The total ILCR is within the target risk range, with the principal contributors being Aroclor-1254 and benzo(a)pyrene.

H.4.5.2 Reference Receptors

The following section presents a summary of risk analyses for hypothetical receptors under the unlikely scenario that land-use controls fail. These receptors have been provided for comparison purposes only. They are not envisioned as being viable under the adopted site-wide remedy.

On-Property Resident Farm Adult

The on-property resident farm adult is based on the assumption that there is complete loss of land-use restrictions. This scenario is the least likely of the reference receptors.

HI and ILCR values for this receptor are presented in Table H.4-6. The total HI (1.0×10^{0}) equals the benchmark of 1. The ingestion of vegetables and fruit has the highest HI value (4.7×10^{-1}), with the principal contributors being magnesium (2.4×10^{-1}) and antimony (1.3×10^{-1}). The ingestion of drinking water has an HI of 1.6×10^{-1}, with the principal contributors being uranium (7.9×10^{-2}) and manganese (7.8×10^{-2}). The ingestion of dairy products has an HI of 2.6×10^{-1}, with the principal contributor being magnesium (2.4×10^{-1}).

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TABLE H.4-4
SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM ADULT[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	NA[c]
Incidental ingestion of residual soils (chemicals)	3.3×10^{-3}
Dermal contact with residual soils (chemicals)	2.1×10^{-2}
Ingestion of meat (chemicals)	7.3×10^{-6}
Ingestion of dairy products (chemicals)	2.6×10^{-2}
Ingestion of vegetables and fruit (chemicals)	3.9×10^{-2}
Ingestion of drinking water (chemicals)	4.7×10^{-2}
Dermal contact while bathing (chemicals)	2.7×10^{-2}
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
RME Individual HI =	1.6×10^{-1}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	2.0×10^{-10}
Inhalation of particulates (radionuclides)	3.1×10^{-7}
Incidental ingestion of residual soils (chemicals)	7.8×10^{-7}
Incidental ingestion of residual soils (radionuclides)	1.4×10^{-7}
Dermal contact with residual soils (chemicals)	1.1×10^{-6}
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	1.9×10^{-6}
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
Incidental ingestion while wading (radionuclides)	NA
Ingestion of meat (chemicals)	1.0×10^{-8}
Ingestion of meat (radionuclides)	2.5×10^{-9}
Ingestion of dairy products (chemicals)	1.3×10^{-5}
Ingestion of dairy products (radionuclides)	1.2×10^{-5}
Ingestion of vegetables and fruit (chemicals)	3.2×10^{-6}
Ingestion of vegetables and fruit (radionuclides)	7.3×10^{-6}
Direct radiation	3.0×10^{-6}
RME Individual Total Risk =	4.3×10^{-5}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

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TABLE H.4-5

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM CHILD[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	NA[c]
Incidental ingestion of residual soils (chemicals)	1.7×10^{-2}
Dermal contact with residual soils (chemicals)	3.4×10^{-2}
Ingestion of meat (chemicals)	1.3×10^{-5}
Ingestion of dairy products (chemicals)	2.7×10^{-1}
Ingestion of vegetables and fruit (chemicals)	1.6×10^{-1}
Ingestion of drinking water (chemicals)	1.1×10^{-1}
Dermal contact while bathing (chemicals)	1.3×10^{-1}
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
RME Individual HI =	7.2×10^{-1}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	4.9×10^{-11}
Inhalation of particulates (radionuclides)	1.6×10^{-8}
Incidental ingestion of residual soils (chemicals)	3.5×10^{-7}
Incidental ingestion of residual soils (radionuclides)	1.3×10^{-8}
Dermal contact with residual soils (chemicals)	1.5×10^{-7}
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	8.2×10^{-8}
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
Incidental ingestion while wading (radionuclides)	NA
Ingestion of meat (chemicals)	1.6×10^{-9}
Ingestion of meat (radionuclides)	8.2×10^{-11}
Ingestion of dairy products (chemicals)	1.2×10^{-5}
Ingestion of dairy products (radionuclides)	2.4×10^{-6}
Ingestion of vegetables and fruit (chemicals)	1.1×10^{-6}
Ingestion of vegetables and fruit (radionuclides)	5.4×10^{-7}
Direct radiation	2.3×10^{-7}
RME Individual Total Risk =	1.7×10^{-5}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

TABLE H.4-6
SUMMARY OF POTENTIAL HEALTH EFFECTS:
ON-PROPERTY RESIDENT FARM ADULT[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	3.8×10^{-5}
Incidental ingestion of residual soils (chemicals)	1.1×10^{-2}
Dermal contact with residual soils (chemicals)	5.4×10^{-2}
Ingestion of meat (chemicals)	8.9×10^{-5}
Ingestion of dairy products (chemicals)	2.6×10^{-1}
Ingestion of vegetables and fruit (chemicals)	4.7×10^{-1}
Ingestion of drinking water (chemicals)	1.6×10^{-1}
Dermal contact while bathing (chemicals)	4.8×10^{-2}
Incidental ingestion while wading (chemicals)	NA[c]
Dermal contact while wading (chemicals)	NA
RME Individual HI =	1.0×10^{0}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	1.6×10^{-9}
Inhalation of particulates (radionuclides)	3.9×10^{-6}
Incidental ingestion of residual soils (chemicals)	2.3×10^{-6}
Incidental ingestion of residual soils (radionuclides)	1.6×10^{-6}
Dermal contact with residual soils (chemicals)	1.4×10^{-6}
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	4.2×10^{-6}
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
Incidental ingestion while wading (radionuclides)	NA
Ingestion of meat (chemicals)	1.3×10^{-8}
Ingestion of meat (radionuclides)	2.9×10^{-9}
Ingestion of dairy products (chemicals)	1.4×10^{-5}
Ingestion of dairy products (radionuclides)	1.9×10^{-5}
Ingestion of vegetables and fruit (chemicals)	1.7×10^{-5}
Ingestion of vegetables and fruit (radionuclides)	2.9×10^{-5}
Direct radiation	1.1×10^{-4}
RME Individual Total Risk =	2.1×10^{-4}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

The total ILCR (2.1×10^{-4}) for this receptor exceeds 10^{-4}, with direct radiation exposure (1.1×10^{-4}) and ingestion of vegetables and fruit (4.6×10^{-5}) being the primary contributors (Table H.4-6). The driving contaminants are radium and thorium for direct radiation exposure with arsenic and strontium driving the ingestion of vegetables.

On-Property Child

The on-property child receptor is assumed to be exposed to the same pathways as the on-property resident farm adult. The total HI for this receptor is 5.4×10^{0} (Table H.4-7) and is primarily a product of ingestion of dairy products (2.7×10^{0}) and ingestion of vegetables (1.9×10^{0}). Magnesium contributes over 75 percent of the total HI. The total ILCR of 3.5×10^{-5} is within the target range of 10^{-6} through 10^{-4}. The ingestion of dairy products chemicals (1.3×10^{-5}) and radionuclides (3.6×10^{-6}) in addition to external radiation (8.4×10^{-6}) are the driving pathways. Aroclor-1254 (6.8×10^{-6}) and benzo(a)pyrene (5.6×10^{-6}) contribute over 90 percent of the chemical risk through the dairy pathway. Technetium (2.2×10^{-6}) and strontium (1.1×10^{-6}) are responsible for over 90 percent of the radiological risk associated with the dairy products. External radiation (8.4×10^{-6}) is attributable to radium concentrations (7.2×10^{-6}).

Commercial/Industrial User

The commercial/industrial user has been provided to better evaluate the postremedial risk impacts under the hypothetical loss of land-use controls and the subsequent development of the FEMP into an industrial facility.

HI and ILCR values associated with the commercial/industrial user are presented in Table H.4-8. The predicted HI (4.3×10^{-2}) is below the level of concern of 1.0. Dermal contact with residual soils (3.8×10^{-2}) is the primary pathway of exposure. Total uranium contributes over 80 percent of the projected noncarcinogenic risk. The total ILCR (2.9×10^{-5}) is within the target risk range of 10^{-6} through 10^{-4}. The major contributor is external radiation (2.8×10^{-5}), with radium responsible for over 85 percent of the total pathway risk.

Developed-Park User

The developed-park user has been provided to address the hypothetical scenario that the postremedial FEMP would be developed into a regional or county park. The total HI for this receptor is 1.1×10^{-2} (Table H.4-9) and is well below the benchmark of 1.0.

The ILCRs for chemical and radioactive COCs are presented in Table H.4-9, with the total for all pathways being within the 10^{-4} to 10^{-6} range. A total ILCR of 4.8×10^{-6} is predicted for this receptor, with the principal contributor being external radiation (4.3×10^{-6}) due to radium (3.7×10^{-6}).

TABLE H.4-7

SUMMARY OF POTENTIAL HEALTH EFFECTS: ON-PROPERTY RESIDENT FARM CHILD[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	1.1×10^{-4}
Incidental ingestion of residual soils (chemicals)	5.9×10^{-2}
Dermal contact with residual soils (chemicals)	8.7×10^{-2}
Ingestion of meat (chemicals)	1.6×10^{-4}
Ingestion of dairy products (chemicals)	2.7×10^{0}
Ingestion of vegetables and fruit (chemicals)	1.9×10^{0}
Ingestion of drinking water (chemicals)	3.7×10^{-1}
Dermal contact while bathing (chemicals)	2.2×10^{-1}
Incidental ingestion while wading (chemicals)	NA[c]
Dermal contact while wading (chemicals)	NA
RME Individual HI =	5.4×10^{0}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	3.8×10^{-10}
Inhalation of particulates (radionuclides)	2.0×10^{-7}
Incidental ingestion of residual soils (chemicals)	1.0×10^{-6}
Incidental ingestion of residual soils (radionuclides)	1.6×10^{-7}
Dermal contact with residual soils (chemicals)	2.0×10^{-7}
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	1.8×10^{-7}
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
Incidental ingestion while wading (radionuclides)	NA
Ingestion of meat (chemicals)	2.0×10^{-9}
Ingestion of meat (radionuclides)	9.8×10^{-11}
Ingestion of dairy products (chemicals)	1.3×10^{-5}
Ingestion of dairy products (radionuclides)	3.6×10^{-6}
Ingestion of vegetables and fruit (chemicals)	5.9×10^{-6}
Ingestion of vegetables and fruit (radionuclides)	2.1×10^{-6}
Direct radiation	8.4×10^{-6}
RME Individual Total Risk =	3.5×10^{-5}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

TABLE H.4-8
SUMMARY OF POTENTIAL HEALTH EFFECTS:
COMMERCIAL/INDUSTRIAL USER[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	NA[c]
Incidental ingestion of residual soils (chemicals)	4.5×10^{-3}
Dermal contact with residual soils (chemicals)	3.8×10^{-2}
Ingestion of meat (chemicals)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of drinking water (chemicals)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
RME Individual HI =	4.3×10^{-2}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	1.1×10^{-10}
Inhalation of particulates (radionuclides)	1.8×10^{-7}
Incidental ingestion of residual soils (chemicals)	3.3×10^{-7}
Incidental ingestion of residual soils (radionuclides)	2.3×10^{-7}
Dermal contact with residual soils (chemicals)	3.7×10^{-7}
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
Incidental ingestion while wading (radionuclides)	NA
Ingestion of meat (chemicals)	NA
Ingestion of meat (radionuclides)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of dairy products (radionuclides)	NA
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of vegetables and fruit (radionuclides)	2.8×10^{-5}
Direct radiation	
RME Individual Total Risk =	2.9×10^{-5}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

000090

TABLE H.4-9
SUMMARY OF POTENTIAL HEALTH EFFECTS:
DEVELOPED-PARK USER[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	NA[c]
Incidental ingestion of residual soils (chemicals)	4.8×10^{-4}
Dermal contact with residual soils (chemicals)	9.1×10^{-3}
Ingestion of meat (chemicals)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of drinking water (chemicals)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	5.7×10^{-4}
Dermal contact while wading (chemicals)	1.6×10^{-3}
RME Individual HI =	1.2×10^{-2}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	1.7×10^{-11}
Inhalation of particulates (radionuclides)	1.6×10^{-8}
Incidental ingestion of residual soils (chemicals)	9.7×10^{-8}
Incidental ingestion of residual soils (radionuclides)	3.6×10^{-14}
Dermal contact with residual soils (chemicals)	2.4×10^{-7}
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	4.2×10^{-8}
Dermal contact while wading (chemicals)	9.6×10^{-10}
Incidental ingestion while wading (radionuclides)	6.4×10^{-8}
Ingestion of meat (chemicals)	NA
Ingestion of meat (radionuclides)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of dairy products (radionuclides)	NA
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of vegetables and fruit (radionuclides)	NA
Direct radiation	4.3×10^{-6}
RME Individual Total Risk =	4.8×10^{-6}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

Wildlife-Reserve User

The wildlife-reserve user has been provided to evaluate the postremedial risk associated with the hypothetical development of the FEMP into a wildlife reserve. The HI and ILCR values associated with this receptor are presented in Table H.4-10.

The projected total HI (9.1×10^{-3}) is below the benchmark of 1.0. The primary pathway and COC is dermal contact with soils (6.9×10^{-3}), specifically dermal contact with residual uranium (5.6×10^{-3}) concentrations.

External radiation (1.6×10^{-6}) is the driving pathway for the total ILCR (1.8×10^{-6}). Radium (1.4×10^{-6}) and thorium (1.6×10^{-6}) are the major contributors. The ILCR is within the total risk range of 10^{-4} to 10^{-6}.

Expanded Trespasser

The expanded trespasser receptor is based on continued federal ownership and land use of the post-remedial facility.

The total HI for this receptor is 1.4×10^{-2}, below the 1.0 benchmark. Dermal contact with residual soils (9.9×10^{-3}) contributes over 70 percent of the total HI with uranium (8.1×10^{-3}) as the driving COC.

A total ILCR of 1.5×10^{-6} is estimated, with on-site external radiation (1.2×10^{-6}) contributing 80 percent of the ILCR. This falls within the 10^{-4} to 10^{-6} target risk range (Table H.4-11).

Milk and Meat Consumer

The milk and meat receptor (Table H.4-12) has been included to evaluate exposures to a hypothetical consumer of the on-property food products. The total HI for this receptor (2.6×10^{-1}) is well below the HI benchmark of 1.0. Magnesium (2.4×10^{-1}) contributes over 90 percent of the total HI through the dairy pathway. The ingestion of dairy products (3.3×10^{-5}) contributes 100 percent of the total ILCR (3.3×10^{-5}). The primary chemical and radionuclide contributors include Aroclor-1254 (7.5×10^{-6}), benzo(a)pyrene (6.5×10^{-6}), arsenic (2.1×10^{-7}), technetium (1.1×10^{-5}), strontium (5.9×10^{-6}), and radium (1.2×10^{-6}). The total ILCR (3.3×10^{-5}) is within the risk range of 10^{-6} through 10^{-4}.

Great Miami River User

The Great Miami River user (Table H.4-13) has been provided to evaluate the potential additive exposure associated with the use of the Great Miami River for agricultural, residential, and recreational purposes. The total HI for this receptor (6.6×10^{-1}) is driven by the ingestion of fish (3.9×10^{-1}) and the ingestion of dairy products (2.3×10^{-1}). Mercury provides over 90 percent of

noncarcinogenic risk to each of these respective pathways. Ingestion of dairy products (5.5×10^{-5}) containing technetium (3.4×10^{-5}) and strontium (2.1×10^{-5}) provide 100 percent of the receptors total ILCR (5.5×10^{-5}).

TABLE H.4-10
SUMMARY OF POTENTIAL HEALTH EFFECTS: WILDLIFE-RESERVE USER[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	NA[c]
Incidental ingestion of residual soils (chemicals)	1.2×10^{-4}
Dermal contact with residual soils (chemicals)	6.9×10^{-3}
Ingestion of meat (chemicals)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of drinking water (chemicals)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	5.7×10^{-4}
Dermal contact while wading (chemicals)	1.6×10^{-3}
RME Individual HI =	9.1×10^{-3}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	5.0×10^{-12}
Inhalation of particulates (radionuclides)	6.4×10^{-9}
Incidental ingestion of residual soils (chemicals)	2.4×10^{-8}
Incidental ingestion of residual soils (radionuclides)	1.3×10^{-14}
Dermal contact with residual soils (chemicals)	1.8×10^{-7}
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	4.2×10^{-8}
Dermal contact while wading (chemicals)	9.6×10^{-10}
Incidental ingestion while wading (radionuclides)	6.4×10^{-8}
Ingestion of meat (chemicals)	NA
Ingestion of meat (radionuclides)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of dairy products (radionuclides)	NA
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of vegetables and fruit (radionuclides)	NA
Direct radiation	1.6×10^{-6}
RME Individual Total Risk =	1.9×10^{-6}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

000094

TABLE H.4-11
SUMMARY OF POTENTIAL HEALTH EFFECTS: EXPANDED TRESPASSER[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	NA[c]
Incidental ingestion of residual soils (chemicals)	1.8×10^{-4}
Dermal contact with residual soils (chemicals)	9.9×10^{-3}
Ingestion of meat (chemicals)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of drinking water (chemicals)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	9.1×10^{-4}
Dermal contact while wading (chemicals)	2.5×10^{-3}
RME Individual HI =	1.4×10^{-2}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	4.2×10^{-12}
Inhalation of particulates (radionuclides)	4.6×10^{-9}
Incidental ingestion of residual soils (chemicals)	2.2×10^{-8}
Incidental ingestion of residual soils (radionuclides)	1.2×10^{-8}
Dermal contact with residual soils (chemicals)	1.7×10^{-7}
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	4.2×10^{-8}
Dermal contact while wading (chemicals)	9.6×10^{-10}
Incidental ingestion while wading (radionuclides)	6.4×10^{-8}
Ingestion of meat (chemicals)	NA
Ingestion of meat (radionuclides)	NA
Ingestion of dairy products (chemicals)	NA
Ingestion of dairy products (radionuclides)	NA
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of vegetables and fruit (radionuclides)	NA
Direct radiation	1.2×10^{-6}
RME Individual Total Risk =	1.5×10^{-6}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

000095

TABLE H.4-12
SUMMARY OF POTENTIAL HEALTH EFFECTS: MILK AND MEAT CONSUMER[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	NA[c]
Incidental ingestion of residual soils (chemicals)	NA
Dermal contact with residual soils (chemicals)	NA
Ingestion of meat (chemicals)	8.9×10^{-5}
Ingestion of dairy products (chemicals)	2.6×10^{-1}
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of drinking water (chemicals)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
RME Individual HI =	2.6×10^{-1}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	NA
Inhalation of particulates (radionuclides)	NA
Incidental ingestion of residual soils (chemicals)	NA
Incidental ingestion of residual soils (radionuclides)	NA
Dermal contact with residual soils (chemicals)	NA
Ingestion of drinking water (chemicals)	NA
Ingestion of drinking water (radionuclides)	NA
Dermal contact while bathing (chemicals)	NA
Incidental ingestion while wading (chemicals)	NA
Dermal contact while wading (chemicals)	NA
Incidental ingestion while wading (radionuclides)	NA
Ingestion of meat (chemicals)	1.3×10^{-8}
Ingestion of meat (radionuclides)	2.9×10^{-9}
Ingestion of dairy products (chemicals)	1.4×10^{-5}
Ingestion of dairy products (radionuclides)	1.9×10^{-5}
Ingestion of vegetables and fruit (chemicals)	NA
Ingestion of vegetables and fruit (radionuclides)	NA
Direct radiation	NA
RME Individual Total Risk =	3.3×10^{-5}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

000096

TABLE H.4-13
SUMMARY OF POTENTIAL HEALTH EFFECTS:
GREAT MIAMI RIVER USER[a]

Exposure Pathway	RME Receptor HI[b]
Inhalation of particulates (chemicals)	NA[c]
Incidental ingestion of residual soils (chemicals)	NA
Dermal contact with residual soils (chemicals)	NA
Ingestion of meat (chemicals)	3.5×10^{-6}
Ingestion of dairy products (chemicals)	3.1×10^{-5}
Ingestion of vegetables and fruit (chemicals)	1.2×10^{-3}
Ingestion of fish (chemicals)	3.9×10^{-1}
Ingestion of drinking water (chemicals)	8.1×10^{-3}
Dermal contact while bathing (chemicals)	1.5×10^{-3}
Incidental ingestion while wading (chemicals)	7.8×10^{-11}
Dermal contact while wading (chemicals)	5.1×10^{-10}
RME Individual HI =	3.9×10^{-1}

Exposure Pathway	RME Receptor Total Risk
Inhalation of particulates (chemicals)	NA
Inhalation of particulates (radionuclides)	NA
Incidental ingestion of residual soils (chemicals)	NA
Incidental ingestion of residual soils (radionuclides)	NA
Dermal contact with residual soils (chemicals)	NA
Ingestion of drinking water (chemicals)	2.2×10^{-7}
Ingestion of drinking water (radionuclides)	2.9×10^{-7}
Dermal contact while bathing (chemicals)	6.3×10^{-9}
Incidental ingestion while wading (chemicals)	7.8×10^{-11}
Dermal contact while wading (chemicals)	5.1×10^{-10}
Incidental ingestion while wading (radionuclides)	4.4×10^{-11}
Ingestion of meat (chemicals)	5.0×10^{-13}
Ingestion of meat (radionuclides)	2.4×10^{-12}
Ingestion of dairy products (chemicals)	1.3×10^{-10}
Ingestion of dairy products (radionuclides)	1.5×10^{-8}
Ingestion of vegetables and fruit (chemicals)	3.3×10^{-8}
Ingestion of vegetables and fruit (radionuclides)	4.5×10^{-8}
Ingestion of fish (chemicals)	1.6×10^{-7}
Ingestion of fish (radionuclides)	8.9×10^{-10}
Direct radiation	NA
RME Individual Total Risk =	7.7×10^{-7}

[a] All risk values include a correction for radionuclides and inorganic background concentrations.
[b] HI = Hazard Index.
[c] NA = Not applicable. Exposure route is incomplete.

H.5.0 UNCERTAINTY ANALYSIS

The risk assessment process contains various sources of uncertainty affecting the accuracy of the projected risks. The uncertainties related to the risk analysis for the Operable Unit 5 CRARE are complex since this operable unit must build upon assumptions and estimates for the remediation and residual contamination from all operable units at the FEMP. Understanding the inherent uncertainty in these comprehensive risk estimates is vital in making informed risk management decisions. The sources and characteristics of uncertainty in the CRARE are examined in this section. Section H.5.1 outlines the principal sources of uncertainty and subsequent sections discuss each source in detail. Section H.5.11 presents a summary table of the uncertainties. The purpose of this analysis is to determine the reliability of risk estimates and to further the reader's understanding of the complexities inherent to risk calculations.

H.5.1 PRINCIPAL SOURCES OF UNCERTAINTY

Major sources of uncertainty in predicting future exposures associated with the site-wide incremental risk assessment include the future disposition of the property, containment of waste left on site, the nature and concentration of residual waste, and the accuracy of the fate and transport modeling used to develop the exposure-point concentrations for the risk assessment. Because it is not possible to definitively predict future land use, configuration and long-term effectiveness of waste containment facilities, or future conditions for containment and transport of COCs, the RME scenario was evaluated. This approach is stipulated by the NCP (EPA 1990c) and the RAWPA (DOE 1992a). For the major categories of uncertainty in the CRARE, the following questions were asked to determine the degree of uncertainty in the evaluation:

- Selection of the PRA/LRAs:
  Are the PRA/LRAs reasonable enough such that potential changes made as a result of comments by agencies and the public will have minimal impact on the overall risk estimates?

- Postremedial Site Configuration:
  How will the final footprint of residual soil and the design and placement of the on-site disposal cell effect the estimate of incremental risks? What environmental changes will occur in the area around the FEMP over the next 1000 years?

- Contents of the On-Site Disposal Cell:
  Are the adopted Operable Unit 5 Waste Acceptance Criteria (WAC) appropriate for the type, contaminant concentrations, and volumes estimated for disposal into the on-site disposal cell?

- Selection of Constituents of Concern:
  Are all the COCs identified and their concentrations adequately quantified?

- Distribution of Contaminants in Environmental Media:
  How will the distribution of COCs in environmental media effect estimates of risk?

- Exposure Assumptions:
  Are all potential pathways for transporting residual contaminants from the site environmental media to receptors identified? Are land-use scenarios conservative and have potential receptors been identified to adequately support land-use objectives? Are exposure factors reasonable?

- Modeled Exposure Point Concentrations:
  Are models for estimating COC transport from site media to receptors, and for estimating contaminant concentrations and intakes, reasonable? How have background concentrations been evaluated? Are the biouptake models for determining COC concentrations in food products reasonable?

- Toxicological Information:
  How accurate is current information concerning toxic properties and dose-response characteristics of the COCs? Are the toxicity factors (slope factors and reference doses) overly conservative? Can noncarcinogenic effects be segregated on the basis of target-organ impacts?

- Risk Characterization:
  Is the assumption of additive effects realistic?

Risk evaluation in the context of an FS takes a different approach than that employed in a baseline risk assessment. The FS risk evaluation hypothesizes and estimates exposure-point concentrations using models and assumptions of postremedial site conditions. Baseline risk assessments generally assume existing site conditions, with no remediation, when evaluating current and future risks.

FS risk assessments assume cleanup to prescribed levels and project into the future. This process has much more inherent uncertainty with regard to exposed populations, exposure pathways, and exposure concentrations than the results of a typical baseline risk assessment. One purpose of this analysis is to identify and characterize the sources of uncertainty which contribute most to the overall uncertainty in the CRARE process. This information can then be used in the risk management decisions involved in evaluating remedial alternatives.

H.5.2 SELECTION OF THE PRA/LRAs

At the present time only Operable Unit 4 has a conditionally approved Record of Decision (ROD). The PRAs for Operable Units 1 and 2 are currently under review by the EPA, and changes may be required in response to regulatory agency comments. In addition, Operable Unit 3 has yet to complete the RI/FS process and develop a PRA. Following the completion of the regulatory agency review, there will be public comment sessions. Comments from this public forum may also impact

the final selection and design of remedial alternatives. The impact of these changes could have significant implications on the determination of overall site-wide risks due to the alterations in the preferred remedial alternatives and eventually, the postremedial site conditions. Currently, no speculation can be made concerning the nature of future comments and potential changes to postremedial site conditions. However, the process of regulatory and public review and comment is intended as a reality check for the remedial planning process. The overall impact of this process should result in the reduction of uncertainty and ensure that the final site-wide remediation is protective.

H.5.3 POSTREMEDIAL SITE CONFIGURATION

The CRARE risk evaluation hypothesizes and estimates exposure point concentrations using models and assumptions of postremedial site conditions. For the site-wide remedy, an estimated 1.80 million cubic yards of contaminated soil be will excavated and clean backfill brought in to regrade excavated areas. Under this remedial approach, it is assumed that surface soil in the backfilled areas will only present background source terms to receptors. Groundwater will be the major impacted medium at the FEMP site resulting from percolation of the residual contaminants in the soil and disposal cell to underlying groundwater. Since groundwater will be of great importance in estimating postremedial risk, factors which effect the modeled COC concentrations in groundwater are significant sources of uncertainty.

Under the Operable Unit 5 remedial alternative, the selected postremedial land use for the FEMP is an undeveloped park. The federal government will retain ownership of the land and no development of the land as a farm, residence, or commercial/industrial facility will be permitted. The Fernald Citizens Task Force for the FEMP is charged with providing future land use recommendations and will issue recommendations on the projected land use for the FEMP in the near future. If the land-use objective is changed, then the remedial objectives will change and the resultant risk estimates will change. One of the major uncertainties for this FS and the CRARE is the ultimate land use for the FEMP.

The location and design of the on-site disposal cell will influence the estimate of potential COC impacts to groundwater. Since geologic subsurface conditions vary across the site, model parameters used in the fate and transport analysis (e.g., soil diffusion coefficients, groundwater flow rates, waste containment, and exfiltration rates) will be influenced by the location, configuration, and design specifications of the engineered disposal cell.

In this study, the disposal cell has been engineered and placed in a specific location to minimize transport of COC to the groundwater which minimizes the impact of the disposal cell on the Great Miami Aquifer.

Projections of COC concentrations in groundwater are a function of source loading from residuals in subsurface soils following excavation. Therefore, the final footprint of excavation and areas of unexcavated residual concentrations will be critical to modeling future contaminant impacts to groundwater. The footprint for excavation is based on PRLs established for the land-use objective and each target receptor. The volume of soil requiring excavation was determined to ensure that the PRL would be the maximum contaminant concentration left in residual soils. Since a majority of the excavated areas will contain contaminant concentrations which are actually lower than the PRLs, modeled groundwater concentrations will be based on a conservative source term estimate.

The chemical species of COCs in the disposal cell and residual soils will also influence the estimate of future contaminant concentrations in groundwater. Partitioning coefficients (e.g., K_d and K_l) which are unique for each COC, were obtained from studies conducted at the site or from conservative values reported in the scientific literature. K_d and K_l values obtained in this manner will ensure calculated risk estimates remain protective to human health.

Another uncertainty with regard to the postremedial configuration of the FEMP site are the regional changes which are likely to occur in the area over the next 1000 years. The CRARE estimates site-wide risks 1000 years after remediation is complete. During this time, unknown changes in the demographics and environmental habitats both on and off site will occur. It is impossible to project how these changes will impact future risk estimates; however, the consideration of multiple hypothetical receptors should cover a variety of possible scenarios, thereby reducing the impact of this uncertainty.

H.5.4 CONTENTS OF THE DISPOSAL CELL

As remediation proceeds at the site, contaminated materials from Operable Units 1 through 4 will either be placed in the on-site disposal cell or sent to an off-site disposal facility. Only those materials which meet the Operable Unit 5 WAC will be placed in the on-site disposal cell. WAC are based on the type, source, and volume of waste, the protectiveness goals (MCLs) for the underlying aquifer, and intended land-use objective and receptors. All waste placed in the on-site disposal cell would be evaluated to the extent practical to ensure that it meets the Operable Unit 5 WAC. The disposal cell will be designed to last 1000 years and prevent physical intrusion to the cell contents. It is predicted that the disposal cell has a 12 percent probability that failure of groundwater protection could occur by the end of the 1000 years.

The WAC directly influence the size of the disposal cell needed to accommodate the combined waste. While the PRA/LRAs influence the treatment design and the volume of waste generated, the Operable Unit 5 WAC influence the type, source, and contaminant concentration of waste which can be placed in the on-site disposal cells. Adherence to WAC would reduce uncertainty and ensure that future projections of postremedial risk are not underestimated.

H.5.5 CONSTITUENTS OF CONCERN IN RESIDUAL WASTE

A major concern of the CRARE is the reliability of COC identification, both in terms of ensuring that chemicals or radionuclides have been correctly identified as COCs and that their potential concentrations in residuals and the disposal cell are adequately quantified. The accuracy of COC identification is directly related to the quality of COC characterization data, including information on contaminant identification, location, and concentrations. COC characterization was controlled by the sampling and analysis plan, which identified sampling locations and defined analytical protocols.

The sources for COC data for the CRARE were the draft final FS report for Operable Unit 2 (DOE 1994b), the SWCR for Operable Unit 3 (DOE 1993a), the final FS reports for Operable Unit 1 (DOE 1994g) and Operable Unit 4 (DOE 1993h), and the draft Operable Unit 5 RI report (DOE 1994b). The draft Operable Unit 5 RI report and backup information from other operable units contributing contaminated material to Operable Unit 5 were prepared according to applicable guidelines under CERCLA. Whenever possible, COC identification was based on the results of the baseline risk assessments which were in turn based on data collected according to operable-unit-specific CERCLA sampling plans. Since Operable Unit 3 has yet to complete its RI and FS reports and Operable Units 1 and 2 are still under agency review, the final list of COCs for Operable Unit 5 may be altered slightly as more information becomes available. However, from the quantitative risk estimates in the documents cited above, it has been estimated that the COCs identified for this site-wide risk assessment constitute more than 95 percent of the total postremedial risk for the site. These COCs were used in estimating site-wide risks.

The 1993 supplemental sampling results and the results of the extensive sampling done at the site make it unlikely that major COC contributors to risk for Operable Unit 5 have been overlooked. Evaluation of existing data has identified a large number of COCs which are present in Operable Unit 5 materials and has confirmed predicted contamination patterns induced by past site operations. There is a fair degree of certainty that the major contaminants (uranium and other radionuclides, arsenic and other metals, and organics) which could credibly contribute to site risks have been identified as COCs.

H.5.6 DISTRIBUTION OF COCs IN ENVIRONMENTAL MEDIA

In the calculation of postremedial site-wide risks, the exposure-point concentrations were assumed not to exceed the PRLs calculated for the land-use objective for which the alternative was designed. For areas of the site that will be excavated and backfilled with clean soils, the exposure-point concentration was assumed to be at background levels for inorganic and radionuclide COCs and at zero for organic COCs. Since the PRL will be the maximum contaminant concentration left on site, future receptors are most likely to be exposed to lower concentrations that vary between background and the PRL. While the baseline risk assessment used the 95 percent UCL of the mean concentration detected (or the maximum concentration detected when less than the 95 percent UCL), based on PRLs, this CRARE used site-wide average contaminant concentrations left on site, minus background concentrations for inorganics and radionuclides. It is highly unlikely that future users of the site will be exposed to maximum residual contaminant levels the entire time they are exposed at the site; therefore, this approach is health protective based upon the proposed land use.

This approach is based on the assumption that inorganic and radionuclide COCs occur naturally in the environment, whereas the organic COCs are assumed to come entirely from made-man, site-related sources. These exposure-point concentrations and corresponding risks represent the incremental risk due to exposures from site residual contaminant concentrations. A separate presentation of total risk, consisting of the incremental risks plus the background risks, is made in Attachment H.V.

H.5.7 EXPOSURE ASSUMPTIONS

The default values for characterizing FEMP receptors are presented in the RAWPA (DOE 1992a) and the Supplemental Guidance to the RAWPA (DOE 1994g). For this CRARE, receptor scenarios were selected to represent the RME scenarios. Exposure factors were based on surveys of physiological and lifestyle profiles across the United States, and the attributes and activities studied generally have a broad distribution. To account for this distribution, the CRARE follows the EPA's recommendation to use the 95th percentile for most exposure parameters.

Calculating RME intakes for the various receptors requires that certain assumptions be made regarding their exposure duration, frequency, and magnitude. Whenever available, standard default values supplied by EPA (EPA 1989a and 1991a) were used. When little information could be found to describe an exposure parameter for a given land use, then conservative, health-protective values suggested by EPA were used as guidance to estimate exposure parameters. This was particularly true for the trespassing and recreational receptors since standard exposure parameters do not exist for these receptors.

Exposure parameters considered available information describing the communities around the FEMP as well as local meteorological conditions. Parameters were selected to support the RME scenario and are therefore higher than what would be expected for other receptors. A discussion of some of the more critical exposure assumptions and their uncertainty follows.

H.5.7.1 Exposure Duration

In accordance with guidance for FEMP risk assessments (DOE 1992a), it was assumed that farm families will occupy the land for a full lifetime (70-year) exposure period. Based on the current residency patterns, this is a highly conservative approach since the national average time for residence in one place is 9 years (EPA 1989a). The 95th percentile value for residence time in the United States is 58.4 years. This value is based on reports published by the Bureau of Census and the Department Housing and Urban Development (Israeli 1992). This exposure duration for farm families was chosen as the RME duration due to the historic stability of communities in the FEMP area and the existence of family farms. It was also assumed that all workers would keep the same jobs without a change of location for 25 years. These estimates of exposure duration are highly conservative based on current work patterns and reflect the upper limits of the job stability of the surrounding communities.

Since there was no existing guidance on the exposure duration for a recreational user, a representative tiered approach was developed to evaluate receptors subjected to exposures in three types of park developments. This approach is assumed to encompass a conservative range of potential risk representing this land use. Again, very conservative assumptions were used for exposure duration. It was assumed people will use the park regularly over an entire lifetime of 70 years. The expanded trespasser was assumed to trespass onto the FEMP site for 12 years as a youth and for 32 years as an adult. As presented in the Monte Carlo analysis of uncertainty (Section H.5.7.7), exposure duration uncertainty is one of the most important factors in the variation of risk estimates.

H.5.7.2 Exposure Frequency

The CRARE assumes that on-property families would occupy the property for 350 days per year, a conservative but realistic assumption for farm families. Workers were assumed to work 250 days a year, the normal number of annual workdays. The expanded trespasser was assumed to trespass onto the FEMP site 110 days a year as a youth and 40 days a year as an adult. This is a conservative but reasonable assumption and only moderately impacts the results of the risk assessment. These exposure frequencies reflect reasonable maximum use of the property for their predicted use patterns. As with the other exposure parameters, frequency values are designed to be conservative and therefore, will generally overestimate potential risk.

H.5.7.3 Exposure Time

Farm family members were assumed to spend 24 hours a day on the farm property, whether it is assumed to be on or off the FEMP property. This is a conservative assumption since it does not take into account school time, shopping time, off-farm work, and other activities. Exposure times for other receptors are uncertain, but were based on their predicted patterns. The exposure values were developed with conservatism and are likely to overestimate potential risk. The exposure time values used in this CRARE are maximum exposure estimates.

H.5.7.4 Body Weight

Body weights used in the evaluation of residual risks were derived from standard tables for United States body weight distributions (EPA 1989a). Values were selected from distribution midpoints because of the certainty regarding those distributions. The actual variation for adults is likely to be less than a factor of two. Although children have a wide range of body weights, the uncertainty is, at most, a factor of two or three (plus or minus for a given age group). Selection of the midpoint (rather than the 95th percentile) for this variable adds conservatism to the risk estimates because this quantity appears in the denominator of the intake equations (i.e., risk is inversely proportional to body weight).

H.5.7.5 Ingestion of Soil, Food, and Water

There has been considerable discussion in the scientific literature concerning the appropriate oral ingestion rate of soil and dust for adults and children. Current EPA guidance recommends 100 mg/day for adults and 200 mg/day for children under the age of six (EPA 1991a). Since the evaluation of residual risk considered farmers who would be exposed to quantities of dust through farming activities, a weighted value of 180 mg/day was used for the on-property farmers (EPA 1991a). These values are realistic as a multi-year average, but soil ingestion rates could potentially be lower for longer-term exposures and peak when crops are being planted or harvested.

The rates and types of food consumption vary greatly from locality to locality and individual to individual. Estimates of food consumption used in the residual risk assessment are based on national averages (EPA 1989a) and may not be appropriate for some individuals exposed to FEMP COCs. It should be noted that it was assumed that the majority of food consumed will be from local farm products. This is a very conservative assumption. The values presented represent conservative estimates and are not likely to vary by more than a factor of two for the average individual. A large uncertainty exits in the consumption of specific foods (e.g., vegetables) by adults and children. The direction and magnitude of this uncertainty are unknown.

The results of the draftOperable Unit 5 baseline risk assessment (DOE 1994f) infer that bioaccumulation of COCs through the food pathways adds a significant contribution to the risk to consumers of food

products (farmers or otherwise). The hypothetical models used to predict food concentrations of COCs add a high degree of uncertainty to the risk estimates. The food uptake models used in this CRARE assume that the airborne particulates are on the surfaces of all food materials, assume uniform distribution of COCs within the plants, assume irrigation throughout the growing season, and assume accumulation occurs over 1000 years. For example, corn is the primary product of farms in the Fernald area, but particulates never come in contact with the corn kernels since the kernels are covered with the shucks. It is estimated that the food pathway estimates are upper bound estimates and not RME estimates.

In addition, the uncertainty is increased because literature default bioaccumulation factors are used as well as the assumption that all chemicals have plant uptake and food transfer mechanisms. For some of the inorganic COCs, the predicted food concentrations are higher than shown by national food surveys, and the COC soil concentrations are at or close to the background soil levels.

Consumption of drinking water was set to EPA default values (EPA 1991a), which are conservative estimates. A value of 2.0 L/day was used, whereas it is estimated that 1.4 L/day is the more likely adult water consumption per day. Over multi-year exposures, these values are not likely to vary widely and may be overestimated by a factor of less than two. Most likely, drinking water consumed will have contaminant levels less than the default values.

H.5.7.6 Dermal Exposure Factors

Four critical assumptions have been made relating to the assessment of dermal exposure to soils: 1) amount of exposed skin surface area, 2) quantity of soil adhering to the skin, 3) length of time the soil adheres to the skin, and 4) partitioning rate of the COC from soil across the skin barrier (EPA 1992f). The amount of the skin assumed to be exposed to COCs used in this CRARE is very conservative for the dermal pathway. The 95th percentile of skin area is used in the dermal absorption models whereas the body weights are average values. The percent of surface area exposed (25 percent) is also conservative because it does not account for seasonal variation. In addition, the intake of contaminants through dermal contact with water is controlled by the dermal permeability of specific waterborne contaminants (EPA 1992f). These factors vary widely and may contribute substantially to uncertainty in a risk assessment using these pathways. In general, assumptions used to estimate dermal absorption are consistent with the conservative default values defined in EPA guidance (EPA 1991a and 1992f). The degree of uncertainty associated with dermal exposure factors is quite large (an order of magnitude or more) (EPA 1992c). In addition, the adjustment of toxicity values for use in the dermal pathways considered in the risk assessment, particularly in the case of inorganic contaminants, was performed using conservative assumptions about contaminant intake. This adjustment will contribute to the conservatism introduced through the characterization of dermal pathway risks.

H.5.7.7 Monte Carlo Analysis of Exposure Parameters

To assess the quantitative impact of the uncertainty for the overall risk model, a limited Monte Carlo analysis of exposure parameters was conducted. This Monte Carlo analysis dealt only with the uncertainties in the exposure assessment and did not examine other elements of the risk assessment such as characterization of the source term, fate and transport analysis of COCs, and toxicity assessment. Therefore, this Monte Carlo analysis examined only one part of the overall uncertainty. The purpose of the quantitative uncertainty analysis was to examine both the magnitude and likelihood of risk-based point estimates. The details of the analysis, including assumptions, methodology, and results are provided in Attachment H.VI.

Monte Carlo analysis is briefly described as a random sampling process of a known or assumed probability distribution. Using this technique and many simulations of the selected values, probability distributions can be developed. These probability distributions can be expressed as histograms or cumulative distributions in which the sum of probabilities versus the target parameter can be displayed. Cumulative probability distributions indicate where the predicted outcome falls within the complete range of possible outcomes. One important limitation of this type of analysis is that it does not distinguish between the variability and uncertainty of specific exposure parameters. Variability arises from natural differences in the population while uncertainty arises from error in the measurement of a parameter or assumption of specific values.

One important finding of the Monte Carlo analysis is the display of the phenomenon of compounded conservatism. In the formation of the RAWPA, many exposure parameters were agreed upon which represent the 95th percentile value for their distribution. This approach was used for the sake of health protectiveness. However, when upper bound estimates of multiple input variables are used, conservatism is propagated and the resulting outcome can severely overestimate true risk. The degree to which an outcome will be overstated is a direct function of the number of inputs, the assumed distributions, the relative uncertainties, correlations between variables, and the upper p-fractile value.

A sensitivity analysis was also conducted to determine which exposure parameters had the greatest impact on the final estimate of risk. The sensitivity analysis identifies those parameters which contributed the most to the variation of the results. The results in this case were the prediction of the PRGs. Distributions for the exposure-related input variables were developed with the exclusion of the food pathways. Following 1000 simulations (i.e., 1000 selections from the distributions) using a Monte Carlo selection technique, the program determined a rank order correlation coefficient between the predicted PRG and the exposure parameter.

This analysis showed that for the on-property farmer, the estimated PRG used for the cleanup goals may be overestimated by a factor of seven if a true 95th percentile value is the target and not the combination of multiple RME exposure parameters. Of the seven exposure parameters analyzed, the key exposure assumptions leading to this overconservatism are exposure duration and the shielding factor for time spent indoors. Although several of other factors will contribute to the overall uncertainty of the exposure estimate, the predominance of these two factors on the estimate of exposure is a quantitatively important area of uncertainty.

It should be noted that two important areas of uncertainty and possible overconservative use of risk parameters were not covered in this Monte Carlo analysis: the conservatism of the toxicology parameters (slope factor and reference dose) and the food pathways. The food pathway risk is a significant contributor to the total risk for some of the inorganic COCs such as arsenic, magnesium, and manganese.

H.5.8 MODELED EXPOSURE-POINT CONCENTRATIONS

Future receptor concentrations cannot be quantified by direct measurement. Therefore, in addition to the media-specific cleanup levels which define the site conditions after the remediation, model- predicted future contaminant migration from residual contamination left on site and in the disposal cell are determined for the CRARE. The cumulative future concentrations at the receptor locations from residual contamination and presence of the on-site disposal facility were quantified using fate and transport modeling of air, surface water, and groundwater. Each of these models was based on a set of general assumptions necessary to simplify the modeling process; however, the models are considered conservative for risk assessment purposes.

Conservative assumptions in the groundwater modeling, such as no contaminant retardation or attenuation in the weathered zone minimum gray-clay thickness for determining infiltration rates through overburden and no constraint on leachate concentrations by theoretical solubility limits, were incorporated in the modeling to ensure that the future contaminant concentration at the receptor locations were not underestimated. Similarly, conservative assumptions were made for the air and surface water models (see Section H.3.0 for details). While reliance on modeled values for future receptor concentrations does increase the uncertainty of the risk estimate, conservative assumptions built into the models ensure that future receptor exposure point concentrations are not likely to be underestimated.

For example, a comparison of modeled base case air concentrations with currently measured air concentrations of radionuclides at the fenceline is presented in Table H.3-6. This comparison indicates that the air fate and transport modeling significantly overestimates concentrations of several particulate-

phase contaminants. Specifically, the modeled base case air concentrations of radium, thorium, and uranium exceed currently measured values at target locations by approximately two orders of magnitude.

Overestimation of the modeled air concentrations may be caused by conservative estimates of contaminant concentrations in the remediated FEMP surface soil. The baseline surface soil concentrations for considered COCs obtained from the draft Operable Unit 5 RI report typically represent the 95 percent UCL or maximum sampling result for each of the source areas. These source areas were originally developed for surface water runoff modeling in the draft Operable Unit 5 RI report. Area-weighted averaging was used to estimate residual postremedial concentrations. A larger area that had relatively high baseline concentrations could produce a substantial exposure-point concentration after excavation, even though much of the area will have undergone excavation. Developing source areas that better delineate contaminated areas from uncontaminated areas will produce residual exposure- point concentrations that are significantly lower than the modeled values presented in this FS report.

Values used to represent exposure-point concentrations were developed to provide conservative, often worst-case estimates of exposure. Uncertainties associated with exposure-point concentrations estimated by models are additive or multiplicative and include uncertainties associated with each input parameter (e.g., diffusion coefficients, groundwater flow rates, waste containment, and exfiltration rate), as well as model characteristics, release mechanisms, and source terms. The development of chemical concentrations for each of 33 subunits on an individual basis, in support of the groundwater fate and transport modeling, has unknown impacts on the exposure concentration data used in the risk assessment. It does potentially increase the variability of the data from subunit to subunit. Residual risk evaluation input parameters were based on site information and health-protective estimates and were designed to be conservative. Input parameters and models were selected and used in a manner consistent with the RAWPA.

Organic compounds are COCs for this risk analysis. It is well established that biodegradation is an important fate mechanism for organic compounds. However, biodegradation of organic compounds was not considered for the 1000-year analysis except in the food pathways. With the exception of PAHs, PCBs and dioxins, most organic compounds will have biodegraded within the first 100 years. Even the PCBs and PAHs will degrade by 80 to 90 percent within 100 years. These compounds will be an important risk component for the first 70 years, but will not be a risk component for the remainder of the 1000-year period.

Another important uncertainty in the CRARE evaluations is that no radiodecay was taken into account even though residual risks were projected for 1000 years after remedial action. Values used for contaminant levels were estimated for the end of remedial activities, or 22 years after the start of

Operable Unit 5 remediation. Radiodecay is an important process to consider when projecting future risk from radionuclide exposures. Due to radiodecay, isotopes such as Cs-137 and Sr-90 will no longer be present at the site after 1000 years. However, the buildup of daughters from the long-lived parent could offset this.

An evaluation was performed to show the probable impact of radiodecay on risk estimates for future scenarios. This evaluation indicated that when radiodecay is considered, the risk estimates IT could increase by a conservative factor of 20 percent for external radiation exposure and decrease by a factor of three for ingestion. Risk estimates for inhalation would have no impact from decay (see Attachment H.VI.2). The differences between exposure routes are based on the type of radiation each isotope emits, the biological impact of each, and the pathways evaluated. Isotopes that have high external radiation impacts often have minimal effects when taken internally.

H.5.9 TOXICOLOGICAL INFORMATION

EPA-supplied RfDs and cancer slop factors were used throughout the residual risk evaluations. Because of this, toxicological evaluations for residual risk contribute no more uncertainty than in comparable CERCLA documents. However, the level of uncertainty in the toxicologic data and models is still substantial.

When a receptor is simultaneously exposed to more than one contaminant, possible outcomes include synergism, antagonism, or additivity of effects. Synergism occurs when the effect of exposure to multiple COCs is greater than what would be expected if the exposures occurred separately in an additive manner. Antagonism is the opposite case, where multiple exposures have a diminished effect than would be expected if exposures occurred separately. For this risk assessment, it was assumed that multiple contaminant exposures would result in additive effects discounting synergism or antagonism. The assumption of additivity is made to prevent an underestimation of cancer risk or potential noncancer health effects due to exposures (EPA 1991a).

As described in the draft Operable Unit 5 RI report, considerable uncertainty is associated with qualitative (hazard assessment) and quantitative (dose-response) evaluations of Superfund risk assessments. The hazard assessment characterizes the nature and strength of the evidence of causation or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans. The 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 results in animal cancer tests suggest that humans may also manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard

assessment of noncarcinogenic effects, positive animal test results may indicate target tissue and type of adverse human effects (EPA 1989a).

There are many sources of uncertainty in dose-response evaluation of carcinogenic (i.e., slope factor or unit risk calculations) and noncarcinogenic effects (RfD or reference concentration [RfC] calculations). The three major sources are:

1. Interspecies extrapolations:

   Animal-to-human extrapolation, commonly used in the absence of quantitative pharmacokinetics, dosimetric, or mechanistic data, is usually based on a consideration of interspecies differences in body weight, surface area, or basal metabolic rate.

2. Intraspecies or individual variation:

   Most toxicity experiments are performed with animals that are similar in age and genotype so that intragroup biological variation is minimal. However, the human population of concern may reflect a great deal of heterogeneity, including unusual sensitivity to specific toxic effects or contaminants.

   Toxicity data from human occupational studies reflect a bias because only those individuals sufficiently healthy to attend work regularly and those not unusually sensitive to the COCs are likely to be occupationally exposed.

3. Key study and database quality:

   The quality of key studies (from which the quantitative data are derived) and the quality of the literature databases add to the uncertainty. For carcinogenic effects, the uncertainty associated with some quality factors (i.e., group size) is incorporated into the 95 percent upper bound estimate of the slope factor. For noncarcinogenic effects, additional uncertainty factors may be applied in the derivation of the RfDs or RfCs to reflect gaps in the database.

Another source of uncertainty in the quantitative risk estimation for carcinogenicity is the method by which data from high doses in animal or human studies are extrapolated to the dose range expected for environmentally exposed humans. The linear multi-stage model, which is used in almost all quantitative estimations of human risk from animal data, is based on the non-threshold assumption of carcinogenesis. A large body of evidence, however, suggests that epigenetic carcinogens (carcinogens which do not induce mutations) as well as many genotoxic carcinogens may have a threshold dose level below which they are noncarcinogenic (Amdur, et al. 1991). The linear multi-stage model is therefore regarded as being conservative for many chemicals.

Adding to this is the fact that the EPA-derived slope factors found in IRIS (EPA 1994a) are set at the 95 percent UCL of the linear slope of the multi-stage model. Thus, risks evaluated using the slope factors may be overestimated. This consideration applies to both radiological and chemical estimates of carcinogenic risk. The slope factors derived by EPA for the evaluation of risks due to external exposure to radiation are of particular concern in this regard. These values were derived using conservative assumptions about exposure conditions and are likely to provide conservative risk estimates.

The methods used to define RfD values for chemical contaminants also incorporate a large degree of conservatism. Sets of multiplicative uncertainty factors are used to adjust the results of animal and human toxicologic studies to take into account the nature of the endpoint "no observed adverse effect level" (NOAEL) to "lowest observed adverse effect level" (LOAEL) seen in the studies, differences in response to different dose schedules, the presence of especially sensitive populations, and the possible differences between human and animal sensitivity to contaminant exposures. Each uncertainty factor may have a value as high as 10; thus, RfD values typically are set between 100 and 1000 times lower than the lowest dose demonstrated to cause observable adverse effects in animal studies. If the human and animal responses to contaminant exposures are not as dissimilar as reflected in the uncertainty factors (or if humans are less, rather than more, sensitive to contaminants), it is possible that the use of RfDs overstates the potential for adverse health effects in humans.

When exposure to multiple chemicals occurs, the potential for harmful effects is assessed by summing the HQs and this value is designated the HI. In keeping with EPA guidance (EPA 1989a), all non-carcinogenic risk was considered additive. Since the noncarcinogenic COCs found at Operable Unit 5 are associated with various adverse effects, many of which are manifested by distinct target organs and systems, the assumption of additivity of effects may overstate actual risks.

Predicted exposures to arsenic, magnesium, and manganese, which are projected to be present in residual soils and water at or near background concentrations, were responsible for a large proportion of the total HI and chemical risk mainly for the on property farmer and child receptors. This large contribution is due to the conservative assumptions made in the food pathways and the conservative toxicological parameters.

To put the FEMP soil background levels into perspective, they are compared to the results of a nationwide survey of surface soils conducted by Shacklette (1984). According to Shacklette, 48 percent of all samples analyzed for arsenic contained between 6.5 and 16.0 mg/kg arsenic. The representative residual soil concentration used in the Operable Unit 5 CRARE was 7.0 mg/kg arsenic.

Fifty percent of the samples analyzed by Shacklette contained between 3000 and 10,000 mg/kg magnesium. The representative residual soil concentration used in this CRARE was 8640 mg/kg magnesium.

Fifty percent of the samples analyzed by Shacklette contained between 300 and 700 mg/kg manganese. The representative residual soil concentration used in this CRARE was 878 mg/kg manganese. While the 878 mg/kg manganese concentration is greater than the range reported by Shacklette, it is in the range of average natural background (40 to 900 mg/kg) reported in the Toxicological Profile for manganese (ATSDR 1989). Therefore, the 878 mg/kg used as a residual soil concentration is at the high end of natural background levels reported for the continental United States. For each of the elements reported above, ingestion (either direct or via food pathways) is the principal exposure pathways contributing to high estimates of risk. For arsenic, this risk is largely attributable to the ingestion of fruits and vegetables with arsenic from both soil uptake and groundwater irrigation.

The model used to predict the concentration of arsenic in vegetables assumes 1000 years of deposition and irrigation in addition to the arsenic already present in the soils. The predicted concentration of arsenic in the aquifer is the arsenic remaining after 30 years of projected pump-and-treat groundwater remediation. This projection accounts for the very slow mobility of arsenic in the aquifer. The plant uptake model assumes 1000 years of irrigation without any credit for natural rainfall. Since the average rainfall for the FEMP area is 41 inches per year, it is likely that for many years no irrigation would occur or would only be minimal. It was also assumed that the on-property farm family would consume 50 percent of their diet as home grown produce. Since the growing season for Ohio is May through October, it would take extensive canning and freezing operations for the farm family to obtain 50 percent of their annual intake of produce from homegrown sources. The vegetable pathway accounts for 99 percent of the off property farmer's arsenic intake. Since the arsenic levels are at naturally occurring levels for the United States and the water concentrations are roughly twice the MCL for arsenic, it seems unlikely that exposure of arsenic through vegetable consumption would result in adverse health effects predicted by this CRARE. This is especially true when the predicted chronic daily intake for arsenic is within the range for United States food products.

Evaluated estimates of residual risk due to magnesium are entirely due to exposure through the milk and meat pathways with about an equal contribution from each pathway. Elevated estimates of risk due to manganese exposure are primarily due to exposure from the vegetable pathways and water consumption. Both magnesium and manganese are essential elements which are considered to be among the least toxic of trace elements (EPA 1993d). Nuts, cereals, seafood, and meats are high dietary sources of these elements. Since magnesium and manganese are essential elements in food, the body is normally able to maintain concentrations in the body through a complex homeostatic mechanism controlling absorption

and excretion. Different homeostatic mechanisms are used to control magnesium and manganese levels. The prediction of adverse health effects due to magnesium through the milk pathway would require that magnesium be present at such levels as to overwhelm the homeostatic controls of both the dairy cow, and the human receptor. This would be an unlikely prediction given that magnesium is present in the soils at or near background levels.

The conservatism and uncertainty present in the magnesium RfD adds to the conservatism of the predicted magnesium health effects. It is estimated that the RfD is at least five times too conservative due to the assumptions of magnesium absorption and urinary magnesium clearance.

There is also great uncertainty regarding uranium carcinogenicity. As an alpha emitter, uranium is considered to be a carcinogen; however, epidemiological evidence of uranium-induced excess cancers is very difficult to obtain. The human studies of cancer from exposure to uranium frequently reveal a slight excess risk, if any, above the background risk. These uncertainties are not easily demonstrated or quantified.

H.5.10 RISK CHARACTERIZATION

Throughout this risk assessment, potential health effects caused by the simultaneous exposure to multiple on-site COCs were assumed to be additive in nature (EPA 1989a). Uncertainties associated with summing cancer risks or HI for multiple substances are of particular concern in the risk characterization. The assumption of dose additivity ignores possible synergism or antagonism among chemicals and assumes similarity in mechanisms of action. However, information to quantitatively assess chemical interactions are generally lacking. In the absence of adequate information on chemical interactions, EPA guidelines indicate that carcinogenic risks and noncancer HIs should be treated as additive.

H.5.11 OVERALL UNCERTAINTY

Numerous sources of uncertainty have been identified for this CRARE risk assessment (Table H.5-1). Each of these factors has been addressed in a fashion that will ensure that the final estimate of risk is conservative, which means that while the magnitude of uncertainty is high, the likelihood that risks have been underestimated is low.

TABLE H.5-1

UNCERTAINTIES ASSOCIATED WITH ESTIMATED RESIDUAL RISKS FROM OPERABLE UNIT 5

Source of Uncertainty		Magnitude[a]	Expected Direction[b]	Remark
Selection of PRA/LRAs	Regulatory and public review comment	Moderate	Unknown	Will ensure that remedial action is protective, but risk estimates are based on the selected alternative
	OU3 piping	Low	No net effect on conservation	Will be addressed prior to completion of the OU5 remedial action
Postremedial Site Configuration	Final footprint of excavation	High	Increases conservatism	Will influence model groundwater concentrations
	Design and placement of on-site disposal cell	High	Increases conservatism	Will influence model groundwater concentrations
	Environmental changes	High	Unknown	Risk is projected out to 1000 years after remediation is complete
Contents of the On-Site Disposal Cell	Waste acceptance criteria for on-site disposal cell	High	Increases conservatism	WAC for OU5 will determine type, source and volume of waste disposed on-site and may influence selection of PRAs
Constituents of Concern in Residual Waste	Adequacy of database	Low	Increases conservatism	High degree of certainty that major COCs have been identified
Selection of COCs	Adequacy of database	Low to moderate	Unknown	COCs may be underestimated. Principal constituents were identified.
Exposure Pathways	Assumptions for estimating exposure magnitude and duration	Moderate	Increases conservatism	Source term extends for 1000 years past the remediation of other operable units
	Determination of exposure Pathways	Low	Increases conservatism	Receptor and exposure pathway specific.

TABLE H.5-1
(Continued)

Source of Uncertainty		Magnitude[a]	Expected Direction[b]	Remark
Exposure Assumptions	Determination of land use	High	Unknown	Selection of land use is critical to the calculations of residual soils concentrations
		High	Increase conservation	Worst-case scenario assumed for each land-use objective
	Exposure duration	Moderate to High	Increases conservatism	Based on historic stability of surrounding communities, RME exposure durations are high
	Exposure frequency	Moderate	Increases conservatism	Designed to be conservative
	Exposure time	Moderate	Increases conservatism	Designed to be conservative
	Body weight	Low	Decreases conservatism	Derived from standard weight tables
	Ingestion of soil, water & food	Moderate	Increases conservatism	Designed to be conservative
	Dermal exposure factors	High	Increases conservatism	Designed to be conservative
Modeled Exposure-Point Concentrations	Assumptions for fate and transport analysis	High	Increases conservatism	Model assumptions were chosen to be conservative
Exposure-Point Concentrations	Calculated exposure-point concentrations	Moderate	Increases conservatism	Source concentrations based on 95 percent UCL or maximum. Sampling was biased for radiological COCs
Toxicological Information	Dose-response assessment	High	Increases conservatism	Dose-response based on animal data
		Moderate to high	Increases conservatism	Dose-response based on high levels of human or animal intake
		Moderate to high	Increases conservatism	Conservative assumptions made for external exposure
	Other Operable Unit 5 COCs	Low	Increases conservatism	PAHs pose low risk
		Low	Increases conservatism	PCBs pose relatively low risk
		Low	Increases conservatism	Furans/dioxins relatively low risk

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TABLE H.5-1
(Continued)

Source of Uncertainty		Magnitude[a]	Expected Direction[b]	Remark
Risk Characterization	Additivity	Low to moderate	Increases conservatism	Potential health effects driven by few COCs and few exposure pathways
	Failure to consider antagonism	Unknown	Increase conservatism	Data unknown
	Failure to consider synergism	Unknown	Decrease conservatism	Data unknown
	Failure to consider segregation of low HIs	Low	Increases conservatism	HIs dominated by few COCs and exposure pathways
Overall		High	Increases conservatism	High uncertainty from combining low, moderate and highly uncertain parameters

[a] Magnitude is assessed qualitatively based on professional judgment and includes the following:
- Low-impact risk by a factor of 10 or less.
- Moderate-impact risk by a factor of 10 to 100.
- High-impact risk by a factor of 100 or more.

[b] Direction is assessed qualitatively where an increased conservatism increases final health effects calculated in calculated risk assessment.

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H.6.0. SUMMARY AND ANALYSIS OF FINDINGS

This CRARE estimates the incremental human-health risks associated with the FEMP 1000 years after implementation of the adopted site-wide remedy. It takes into account the postremedial or "residual" risk to human receptors from the combined residual sources of the FEMP's five operable units. The results have been summarized and discussed in this section by the following categories:

- Site-wide sources of residual contamination
- Identification of COCs
- Receptors
- Pathways of exposure
- Uncertainty analysis
- Postremedial risk results

H.6.1 SUMMARY OF FINDINGS

H.6.1.1 Site-Wide Sources of Residual Contamination

The primary sources of contamination remaining after site-wide remediation include site soils, groundwater, and the engineered on-site disposal cell (Section H.2.0, Figure H.2-1). Site soils and groundwater are the major sources of COCs for all exposure routes to potential receptors. Exposure routes include inhalation, dermal contact, ingestion, and direct radiation. Section H.4.0 discusses the origin, release mechanisms, and route of transport of these COCs.

H.6.1.2 Identification of COCs

The nature and extent of residual site soil contamination and the waste to be placed in the on-site disposal cell were identified using Appendix R of the SWCR as well as the Operable Unit 1, 2, 4, and 5 RI/FS reports (Section H.2.0, Table H.2-1). Waste to be placed in the on-site disposal cell was traced, by media, from its source and taken into consideration in the development of the CRARE COC list.

A comprehensive list of Operable Unit 5 COCs (Section H.2.0, Table H.2-2) was compiled based on a screening of the contaminants of potential concern (CPCs) quantified in the Operable Unit 5 RI report. If a CPC posed an ILCR greater than 1×10^{-7} or an HI greater than 0.1, it was retained as a COC. This comprehensive list was then further screened. Those COCs that collectively pose more than 95 percent of the baseline risk to receptors were retained on a "short list" of COCs appearing in the CRARE (Section H.2.0, Table H.2-3). The process used for selection of the CRARE COC short list followed guidance provided in RAGS (EPA 1989a). The short-list concept enables risk assessors to provide a detailed analysis of potential risks caused by a manageable number of dominant COCs and avoid "large, unwieldy tables and text that are difficult to read and understand and may distract from the dominant risks presented by the site" (EPA 1989a).

*During groundwater fate and transport analysis (Section H.3.1), the COCs on the comprehensive list were analyzed using screening techniques to determine if significant quantities of COCs would impact groundwater within the 1000-year time frame. Any COCs determined to have potential future impact to the aquifer were included in the short list.

It is likely that volatile and semivolatile organic chemicals will undergo biodegradation or otherwise be removed by fate and transport from the FEMP site 1000 years after remediation. However, a health-protective approach was employed in which volatile and semivolatile COCs were included as COCs to ensure that the residual risk would not be underestimated. The overall approach to COC selection and evaluation assures that it is unlikely that any major contaminants were overlooked or arbitrarily removed.

H.6.1.3 Receptors

The following target and reference RME receptors have been evaluated in this CRARE.

Target Receptors

- Undeveloped-park user
- Off-property resident farm adult
- Off-property resident farm child

Reference Receptors

- On-property farm adult
- On-property resident farm child
- Commercial/industrial user
- Developed-park user
- Wildlife-reserve user
- Expanded trespasser
- Great Miami River user
- Meat and milk user

The complete list of receptors represents a wide array of potential future land uses. Target receptors are those incorporated by design into the adopted site-wide remedy from the Operable Unit 5 representative remedial alternative. They were chosen for specific land-use conditions. The estimated risks for these target receptors provide the means to measure the completeness and effectiveness of the representative remedial alternative. The reference receptors are included in the CRARE to provide an understanding of the magnitude of the potential risks to a variety of receptors in the event FEMP institutional controls fail or land use changes for any reason.

H.6.1.4 Pathways of Exposure

The pathways considered in Operable Unit 5 CRARE include:

- Inhalation of volatile vapors, radon gas, and particulates
- Incidental ingestion of soil, sediment, and surface water
- Dermal contact with soil, sediment, surface water, and groundwater
- External radiation exposure
- Ingestion of groundwater (perched or Great Miami Aquifer)
- Ingestion of farm products (milk, meat, and vegetables and fruit)

While these exposure pathways are receptor-specific, the significant pathways for most receptors are the inhalation of fugitive particulates, consumption of farm products and drinking water, and dermal contact with soils. External radiation is a significant pathway of concern for all on-property receptors.

H.6.1.5 Uncertainty Analysis

The risk assessment process contains various elements that contribute to uncertainty which could potentially impact the accuracy of the risk estimates. Understanding the uncertainties inherent in the development of risk estimates is essential when interpreting the results for risk management decisions.

Principal sources of uncertainty in the Operable Unit 5 CRARE were examined and are presented in Section H.5.0. Uncertainties include the future disposition of the FEMP property and residual wastes, placement of the on-site disposal cell, volume and nature of COCs left in the site soils and disposal cell, accuracy of the fate and transport modeling used in developing the exposure point concentrations, and toxicity of the COCs. A major point of uncertainty and overly conservative assumptions was the modeling of the COC uptake by plants and animals and ultimate transport through the food pathways to the human receptors.

This CRARE employed conservative assumptions and health-protective values obtained from the literature when site-specific values were not available. The approach is consistent with the EPA guidance stipulated in RAGS (EPA 1989a). Adopting these factors ensures that the final estimate of risk is conservative, meaning that while the magnitude of uncertainty is high, the probability that the actual risks have been underestimated is low.

H.6.2 ANALYSIS OF FINDINGS

H.6.2.1 Presentation of Postremedial Risk Results

The objective of the CRARE is to evaluate risk remaining at the FEMP site 1000 years after the conclusion of remedial activities. Potential health effects associated with the postremedial FEMP site were evaluated using three approaches to display the contributions of background concentration to the residual risks calculated for the receptors. These analyses were conducted using the methods established by the EPA (EPA 1989a) and RAWPA (DOE 1992a). The only difference in these three sets of risk calculations is the source terms of the exposure. The results of these calculations are presented in Attachment H.V (Tables H.V-3 to H.V-13).

EPA requires that the characteristics of site residuals be considered in measuring the postremedial health risks (EPA 1988a). RAGS states that "background concentrations (of inorganic chemicals) may present a significant risk, and, while cleanup may or may not eliminate this risk, the background risk may be an

important characteristic to those exposed," and "If background risk might be a concern, it should be calculated separately from site-related risk" (EPA 1989a).

To achieve this goal, three approaches (options) were employed to analyze the species and sources of risk drivers to the residual risks. These results enable the reader to understand the background contribution to the overall risks and distinguish between the portion of the risks induced by the background concentrations of COCs from the portion of risk of FEMP origin. Such information will assist risk managers and the general public in understanding the nature of the predicted risks so that sound risk management decisions can be made.

Option A uses the total predicted COC concentrations at the postremedial site as the source terms in predicting the risk to receptors. The source terms employed include background concentrations of radiological and inorganic COCs as well as those incremental concentrations attributable to the postremedial FEMP site. In other words, the source terms present total predicted concentrations of the COCs.

Option B uses the source terms that include inorganic COCs at their naturally occurring background concentrations as well as the incremental concentrations of COCs attributable to the postremedial FEMP site but has eliminated naturally occurring radionuclides from consideration.

The source terms used in the CRARE approach are concentrations of those constituents directly attributable to the postremedial FEMP site. It excludes the contribution from radionuclides and inorganic COCs at their background concentrations. This option presents the residual excess risk above natural background levels.

[Note: Background radionuclide concentrations are those present in the environment due to natural processes (e.g., weathering of radioactive-material-containing soils, minerals, or rocks) or anthropogenic processes other than those occurred at the site such as nuclear weapons testing. Background inorganics also are direct result of nature weathering of soil and rocks (i.e., minerals), which often leaches out soluble portion of metal inorganic salts and leaves behind less soluble salts or elements. These remaining salts or elements often consist of noncarcinogenic heavy metals (such as iron, calcium, potassium, sodium, lead, magnesium, and manganese) and carcinogenic heavy metals (such as arsenic, nickel, cadmium, and beryllium). While ubiquitous, background concentrations of radionuclides and inorganics do vary considerably from area to area.]

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TABLE H.6-1

SUMMARY OF INCREMENTAL LIFETIME CANCER RISK AND HAZARD INDEX FOR ALL RECEPTORS FROM ALL PATHWAYS, CRARE APPROACH

Target RME Receptor	Incremental Lifetime Cancer Risk	HI
Undeveloped-Park User	2.2×10^{-6}	1.0×10^{-2}
Off-Property Resident Farm Adult	4.3×10^{-5}	1.6×10^{-1}
Off-Property Resident Farm Child	1.7×10^{-5}	7.2×10^{-1}

Reference RME Receptor	Incremental Lifetime Cancer Risk	HI
On-Property Resident Farm Adult	2.1×10^{-4}	$1.0 \times 10^{+0}$
On-Property Resident Farm Child	3.5×10^{-5}	$5.4 \times 10^{+0}$
Commercial/Industrial User	2.9×10^{-5}	4.3×10^{-2}
Developed-Park User	4.8×10^{-6}	1.2×10^{-2}
Wildlife-Reserve User	1.9×10^{-6}	9.1×10^{-3}
Expanded Trespasser	1.5×10^{-6}	1.4×10^{-2}
Great Miami River User	7.7×10^{-7}	3.9×10^{-1}
Meat and Milk User	3.3×10^{-5}	2.6×10^{-1}

H.6.2.2 Presentation of CRARE Approach Results

The estimated site-induced incremental health risks associated with the postremedial FEMP site to both target and reference receptors are presented in Section H.4.0 and summarized below in Table H.6-1.

Target Receptors

After implementation of the site-wide remedy, the undeveloped-park user is estimated to receive a potential ILCR of 2.2×10^{-6} and an HI of 1.0×10^{-2}. The off-property resident farm adult receives a potential ILCR of 4.3×10^{-5} and an HI of 1.6×10^{-1}, while the off-property resident farm child has an ILCR of 1.7×10^{-5} and a HI of 7.2×10^{-1} (Table H.6-1).

Both the noncarcinogenic health effects and ILCRs for the three target receptors are below the threshold values stipulated in the NCP (an HI of 1.0 and an ILCR of 10^{-4} to 10^{-6}). The results clearly indicate that the postremedial site conditions anticipated under the adopted site-wide remedy would not pose unacceptable health risks to the target receptors. The adopted site-wide remedy will effectively remove or consolidate site contamination and therefore reduce the associated risks to a level suitable for the planned land-use scenario.

Reference Receptors

In the unlikely event that FEMP institutional controls fail, the remedial site would still protect seven of the eight reference receptors studied in the CRARE (i.e., the on-property resident farm adult, commercial/industrial user, developed-park user, wildlife-reserve user, expanded trespasser, Great Miami River user, and the meat and milk user). The noncarcinogenic HIs for these seven receptors are all below the benchmark of 1.0, and the potential ILCRs are within the 10^{-4} to 10^{-6} range.

Specifically, the potential HI and ILCR for the commercial/industrial user are 4.3×10^{-2} and 2.9×10^{-5}, respectively. The projected potential HI and ILCR are 1.2×10^{-2} and 4.8×10^{-6} for the developed-park user; 9.1×10^{-3} and 1.9×10^{-6} for the wildlife-reserve user; 1.4×10^{-2} and 1.5×10^{-6} for the expanded trespasser; 3.9×10^{-1} and 7.7×10^{-7} for Great Miami River user; 2.6×10^{-1} and 3.3×10^{-5} for meat and milk user; and $1.0 \times 10^{+0}$ and 2.1×10^{-4} for on-property resident farm adult (Table H.6-1 and Figure H.6-1).

Using the CRARE approach, the only reference receptor that exceeds target risk levels is the on-property resident farm child. The predicted HI for the on-property resident farm child is $5.4 \times 10^{+0}$, and his potential ILCR is estimated at 3.5×10^{-5} which is within the risk range stipulated by the NCP.

H.6.2.3 Discussion of CRARE Approach Results

The results presented in Section H.4.0 (CRARE approach) clearly show that the adopted site-wide remedy will result in health protective risk levels (both carcinogenic risk and noncarcinogenic health effects) for the three target receptors (undeveloped-park user, off-property resident farm adult, and off-property resident farm child). When background levels of inorganic and radionuclide COCs are subtracted out, residual contamination at the remediated FEMP site, including the site soils and the waste stored on-site, will not pose unacceptable health hazards or carcinogenic risks to these target receptors.

As previously mentioned, the CRARE also analyzed the potential health impacts to eight reference receptors for the purpose of evaluating relative risks should the institutional controls fail and/or land use change for some other reason. Although the exposure scenarios for these reference receptors are unlikely in the context of planned land use, and the associated health effects improbable for the same reason, they do provide valuable information to decision makers and the general public in evaluating FEMP land-use objectives and the related health impacts.

The following subsection presents a detailed examination of the COCs and exposure pathways that contribute to the on-property resident farm child's elevated HI. The intent of this discussion is to provide site-specific information regarding the estimated risk values so decision makers and members of the general public can better understand the nature of the risk estimates presented in this report. More significantly, the issues discussed below regarding the on-property resident farm child pertain to all FEMP receptors. This is because the risk estimates for each receptor under each option were derived using the same approach and methodology.

Background Concentration Contribution to HI Under CRARE Approach

Detailed analysis of the on-property resident farm child's HI reveals that food pathways contribute the majority of his predicted potential cancer risk and health hazard. Magnesium in the dairy products and in vegetables and fruits contributes a HI of $2.5 \times 10^{+0}$ and 9.9×10^{-1}, respectively (Attachment H.IV, Tables H.IV-66 and H.IV-68). In other words, magnesium concentration (excluding any contribution from background) induces 65 percent of this receptor's projected HI [(2.5+0.99)/5.4=0.65].

The soil concentration of magnesium used in the CRARE approach is 2820 mg/kg (Attachment H.VI, Table H.IV-60). This means the representative magnesium concentration in the soil at the postremedial FEMP site is 2820 mg/kg higher than the background. However, as presented in Section H.5.9, the representative soil magnesium concentration at the postremedial FEMP site is 8640

mg/kg, which is within the range of national average background concentrations (3000 to 10,000 mg/kg) as reported by Shacklette (1984).

The case clearly shows how a slightly elevated magnesium concentration found at the site soils (although is within the national background average) is responsible for a large proportion of the incremental HI for this hypothetical on-property resident farm child.

H.6.2.4 Presentation of Option A and B Results

Another example presented to examine the impact of background concentrations of inorganic COCs on potential noncarcinogenic health effects is the comparison of the HIs calculated for the same receptor under different options. The predicted HIs and ILCRs of both target and reference receptors under the three options are summarized in Table H.6-2 and graphically illustrated in Figures H.6-1 and Figure H.6-2, respectively. (For details, see Attachment H.V, Tables H.V-3 through H.V-13).

As stated earlier, the source term concentrations used to calculate CRARE residual risk do not include background levels of inorganic and radionuclide COCs. The inclusion of naturally occurring background levels of the inorganic COCs (as calculated in Option A or Option B) results in HIs greater than one for five receptors. These receptors include off-property resident farm adult and child, on-property resident farm adult and child, and the meat and milk user (Table H.6-2 and Figure H.6-1).

Further examination of the HI for the off-property resident farm child calculated under the CRARE approach versus that calculated under Option A or Option B reveals the percentage of the HI due to background COC concentrations versus that due to the FEMP site. For example, for the off-property farm child, the HI changes from 7.2×10^{-1} (CRARE approach) to 1.7×10^{1} (Option A or B) when background concentrations are included in the source term. Expressed another way: 95 percent of this receptor's residual noncarcinogenic risk (as calculated in Option A or Option B) is caused by background levels of inorganic COCs (Table H.6-2).

The above discussion illustrates that the relative risk from natural or anthropogenic sources (man-made but not originating from the site) may be high when compared to the incremental risk associated with above-background levels of site related residual COCs.

Background Concentration Contribution to Cancer Risk Under Options A and B

Careful examination of the on-property resident farm child's potential cancer risk derived under the three Options (Table H.6-2 and Figure H.6-2) provides information critical to the interpretation and management of the projected risks.

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TABLE H.6-2

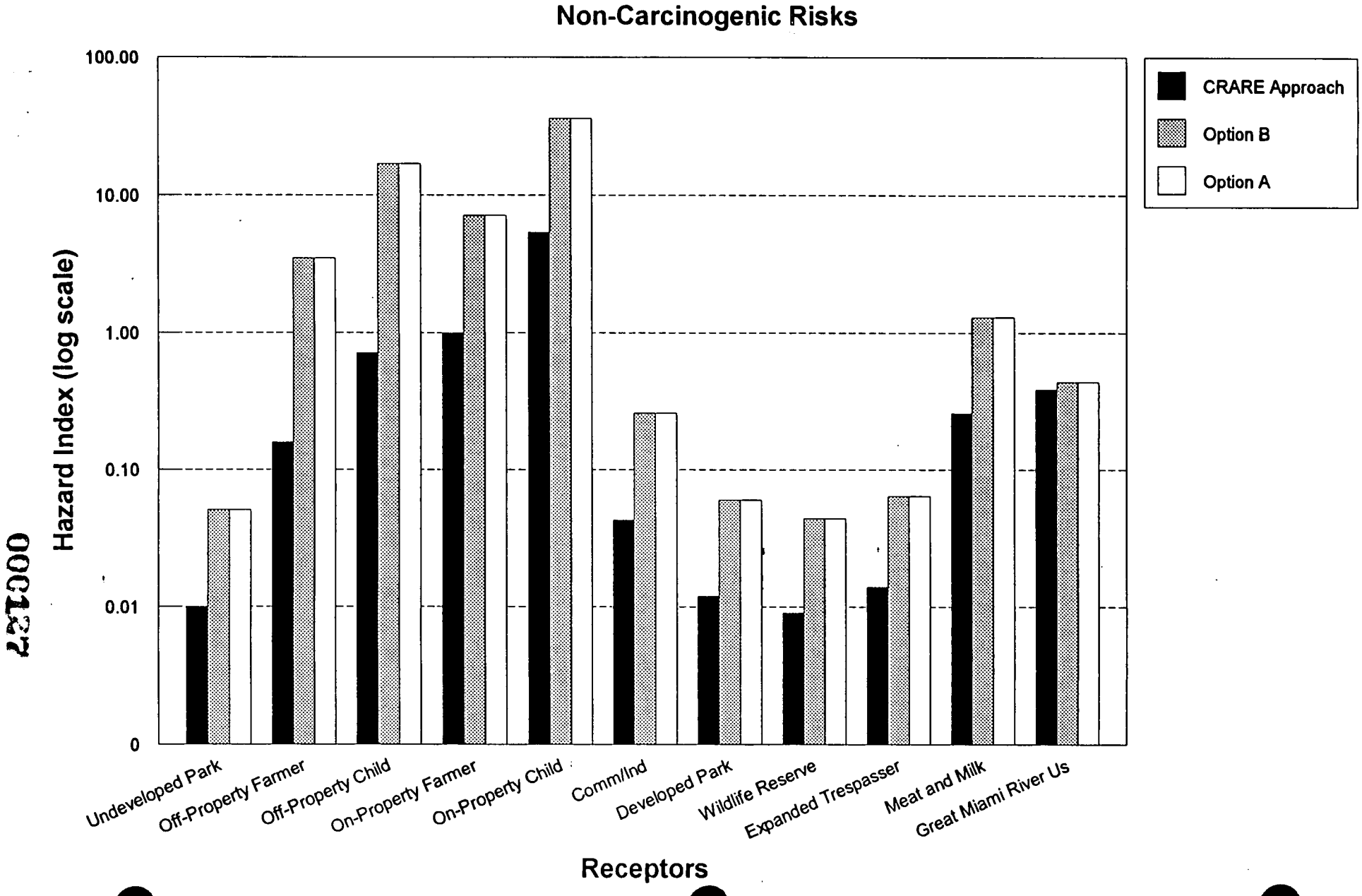
SUMMARY OF INCREMENTAL LIFETIME CANCER RISK AND HAZARD INDEX FOR ALL RECEPTORS FROM ALL OPTIONS

Hazard Index

RME Receptors	Option A	Option B	CRARE Approach
Undeveloped-Park User	5.1×10^{-2}	5.1×10^{-2}	1.0×10^{-2}
Off-Property Resident Farm Adult	$3.5 \times 10^{+0}$	$3.5 \times 10^{+0}$	1.6×10^{-1}
Off-Property Resident Farm Child	$1.7 \times 10^{+1}$	$1.7 \times 10^{+1}$	7.2×10^{-1}
On-Property Resident Farm Adult	$7.1 \times 10^{+0}$	$7.1 \times 10^{+0}$	$1.0 \times 10^{+0}$
On-Property Resident Farm Child	$3.6 \times 10^{+1}$	$3.6 \times 10^{+1}$	$5.4 \times 10^{+0}$
Commercial/Industrial User	2.6×10^{-1}	2.6×10^{-1}	4.3×10^{-2}
Developed-Park User	6.0×10^{-2}	6.0×10^{-2}	1.2×10^{-2}
Wildlife-Reserve User	4.4×10^{-2}	4.4×10^{-2}	9.1×10^{-3}
Expanded Trespasser	6.4×10^{-2}	6.4×10^{-2}	1.4×10^{-2}
Great Miami River User	4.4×10^{-1}	4.4×10^{-1}	3.9×10^{-1}
Meat and Milk User	$1.3 \times 10^{+0}$	$1.3 \times 10^{+0}$	2.6×10^{-1}

Lifetime Cancer Risk

RME Receptors	Option A	Option B	CRARE Approach
Undeveloped-Park User	1.4×10^{-5}	3.0×10^{-6}	2.2×10^{-6}
Off-Property Resident Farm Adult	9.5×10^{-4}	3.2×10^{-4}	4.3×10^{-5}
Off-Property Resident Farm Child	1.6×10^{-4}	1.2×10^{-4}	1.7×10^{-5}
On-Property Resident Farm Adult	1.4×10^{-3}	5.9×10^{-4}	2.1×10^{-4}
On-Property Resident Farm Child	2.4×10^{-4}	1.7×10^{-4}	3.5×10^{-5}
Commercial/Industrial User	2.0×10^{-4}	3.4×10^{-5}	2.9×10^{-5}
Developed-Park User	3.3×10^{-5}	6.5×10^{-6}	4.8×10^{-6}
Wildlife-Reserve User	1.2×10^{-5}	2.6×10^{-6}	1.9×10^{-6}
Expanded Trespasser	9.3×10^{-6}	2.1×10^{-6}	1.5×10^{-6}
Great Miami River User	2.6×10^{-5}	6.5×10^{-6}	7.7×10^{-7}
Meat and Milk User	5.6×10^{-5}	3.9×10^{-5}	3.3×10^{-5}


Non-Carcinogenic Risks
100.00
10.00
1.00
0.10
0.01
0
Hazard Index (log scale)
CRARE Approach
Option B
Option A
Undeveloped Park
Off-Property Farmer
Off-Property Child
On-Property Farmer
On-Property Child
Comm/Ind
Developed Park
Wildlife Reserve
Expanded Trespasser
Meat and Milk
Great Miami River Us
Receptors

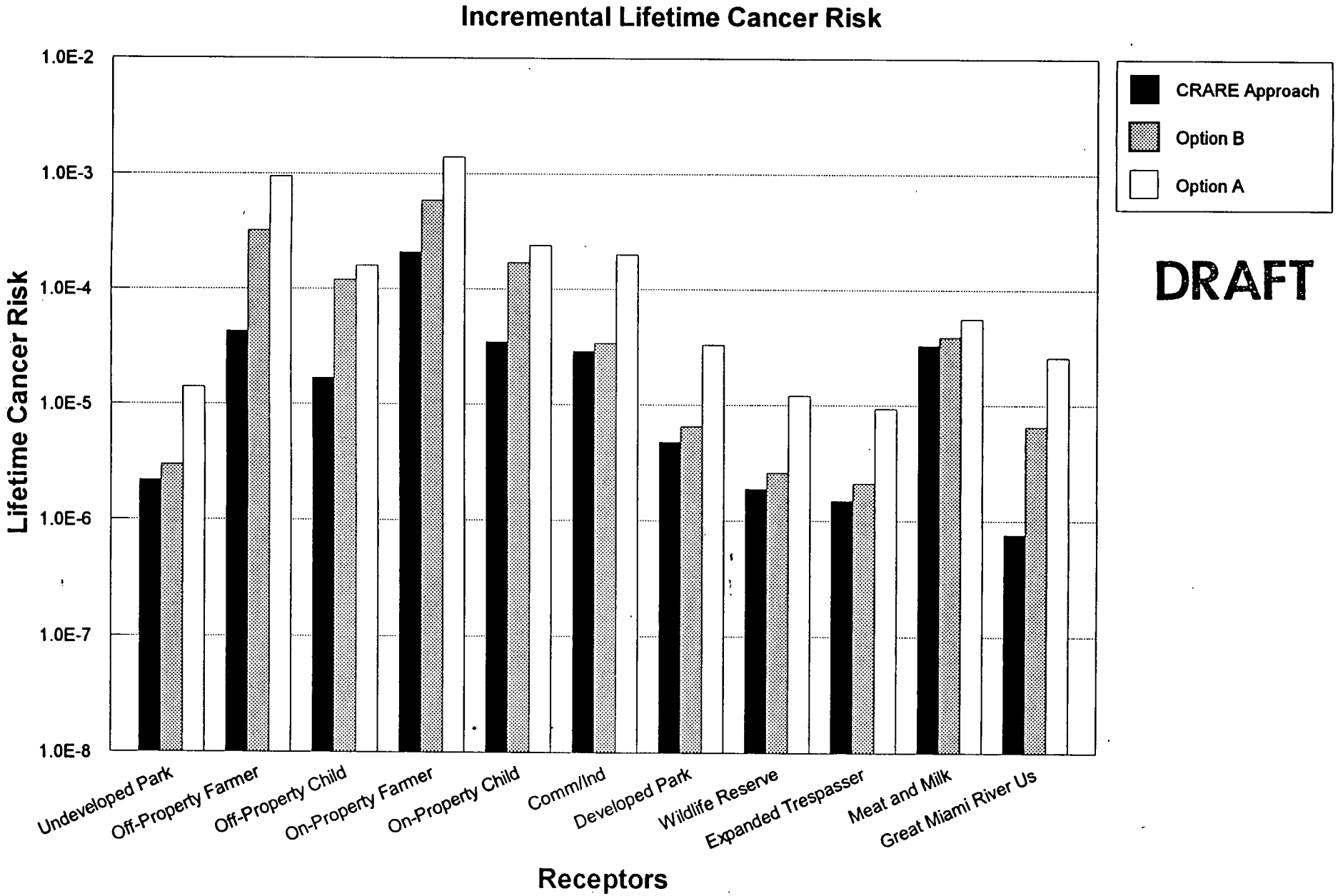


FIGURE H.6-2. COMPARISON OF RECEPTORS FOR DIFFERENT RISK OPTIONS

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The inclusion of naturally occurring background levels of inorganic COCs (as calculated in Option B) results in potential cancer risks greater than 1.0×10^{-4} for four receptors (Table H.6-2 and Figure H.6-2). These receptors are the off-property resident farm adult and child, on-property resident farm adult and child.

To assess the impact of background concentrations of inorganic COCs on the predicted potential cancer risks, the off-property resident farm child was chosen as an example. Using CRARE approach, this receptor's ILCR is estimated at 1.7×10^{-5}. However, if the background levels of the inorganic COCs are included (Option B), the potential cancer risk for this receptor changes to 1.2×10^{-4} (Table H.6-2) which represents a 342 percent increase in the estimated cancer risk over the CRARE approach. In other words, 86 percent of this receptor's potential lifetime cancer risk is caused by background levels of carcinogenic inorganic COCs.

The inclusion of background levels of inorganic and radionuclide COCs results in potential cancer risks greater than 1.0×10^{-4} for five receptors when comparing the results of CRARE approach and the Option A (Table H.6-2 and Figure H.6-2). These receptors include the off-property resident farm adult and child, on-property resident farm adult and child, and commercial/industrial user)

The same argument can be made when considering the overly conservative approach illustrated in Option A, which calculates total risk including the background contributions from radionuclides and inorganic COCs. Such over-conservatism pushes the predicted HI and lifetime cancer risk of the on-property resident farm child from $5.4 \times 10^{+0}$ to $3.6 \times 10^{+1}$ and from 3.5×10^{-5} to 2.4×10^{-4}, respectively. The HI would increase by 660 percent and the lifetime cancer risk by 690 percent.

Comparing these three sets of risk estimates clearly reveals the contribution of background levels of inorganic and radionuclide COCs to the final estimate of residual risk. It also points out the importance of understanding these contributions.

Based on the above discussions, it is clear that the majority of the predicted potential HIs and ILCRs presented in Options A and B are the direct result of including natural and anthropogenic background concentrations of radionuclides and inorganic COCs in the estimates of postremedial risk. Adopting such a concept will result in significant over-estimation of risk values. Without careful review and analysis of the risk results and a complete understanding of the nature and source of the major risk drivers, sound risk management decisions would be more difficult to make.

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H.6.3 CONCLUSIONS AND RECOMMENDATIONS

This CRARE report attempts to evaluate the sources and magnitude of the potential health risks to a range of target and reference receptors associated with the postremedial FEMP site. Several observations or conclusions can be drawn from this analysis:

- The adopted site-wide remedy would not result in unacceptable health hazards or incremental lifetime cancer risks to the three target receptors (i.e., undeveloped-park user, off-property resident farm adult, and off-property resident farm child) or seven of eight reference receptors when background concentration are taken into consideration.

- These findings confirm the completeness and effectiveness of the waste removal and treatment measures proposed in the site-wide remedy and explicitly presented in the Operable Unit 5 representative remedial alternative.

- The on-property resident farm child is the only receptor studied under CRARE approach that may receive an HI and potential lifetime cancer risk higher than the levels generally considered acceptable by regulatory and scientific communities. This exposure scenario is very unlikely since it can occur only if the institutional controls included in the site-wide remedy fail.

- Upon further examination of the predicted HI and lifetime cancer risk for the on-property resident farm child under the three options studied in the report, it becomes clear that the majority of such risk can be directly linked to the way in which background COC concentrations are handled. The consideration of residual inorganic and radionuclide concentrations which are within the range of regional or national background levels is a key issue.

- After subtracting out the portion of the HI and potential lifetime cancer risk attributed to the background radionuclide and inorganic concentrations, the revised HI and ILCR for the on-property farm resident child are within the target ranges stipulated in the NCP.

- Over-conservatism is employed in this CRARE as in other risk assessments. It is imperative that decision makers and the general public understand the nature of the issues so that sound and cost-effective risk management decisions can be made.

- In the event that the background concentrations present a significant risk at a Superfund site, and cleanup may or may not eliminate this risk, the Risk Assessment Guidance for Superfund (EPA 1989a) allows the Remedial Program Manager the option of considering the risk posed by naturally occurring background constituents separately.

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ATTACHMENT H.I
COMPUTER PRINT OUTS
MASS LOADING

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H.I. WATER TRANSPORT MODELING

This attachment presents supplmental information on the methodology, models, and results of the CRARE water transport analysis. The complete approach is described in Section H.3.0.

Section H.I.1 presents the refinements made to the estimations of residual source terms. Section H.I.2 describes the flow, infiltration, and fate and transport models used. Section H.I.3. presents the water modeling results. These exposure-point concentrations, which were used to estimate the risk to potential receptors, are presented in tables and figures (isopleths). Section H.I.4 reproduces the model output for the groundwater mass loading.

H.I.1. Refinements to Operable Unit 5 Source Term Estimations

The final CRARE fate and transport modeling was conducted using refined estimations of residual COC sources. Below is a summary of the adjustments made during the refinement process.

Representative Alternative Based on Screening of Future Loading from the Disposal Cell

- The 4-nitroaniline contamination, which is very mobile, was only detected at the KC-2 Warehouse. Available data do not indicate that the contamination was dispersed over the entire Source Area 560b as modeled in the Operable Unit 5 draft RI report. A volume of 2500 cubic yards was estimated to be contaminated with 4-nitroaniline instead of the entire Source Area 560b. Therefore, the volume-weighted concentrations of 4-nitroaniline in the disposal cell and residual concentration in 560b were revised to better reflect site conditions.

- Based on recent TCLP data and measured concentrations in soil and perched groundwater of Tc-99 (see Appendix F), the K_l value of Tc-99 has been estimated to be 30 L/kg. However, the literature K_d values for clay, sand, and gravel used in the RI were similarly adopted for the CRARE. As a result of these assumptions, the WAC of tc-99 for the disposal cell was determined to be 30 pCi/g. On the basis of the WAC, about 25,000 cubic yards of excavated soil cannot be disposed in the on-site disposal cell and would need to be shipped off-site due to Tc-99 contamination.

- Based on the initial screening, after the above two adjustments to the Operable Unit 5 representative alternative, none of the 14 groundwater pathway COCs would have significant impacts (i.e., higher than drinking water criteria specified in the RRA) to the Great Miami Aquifer due to future loading from the disposal cell (Table H.I-1).

Refinements to the Operable Unit 5 Representative Remedial Alternative Based on Screening of Direct Contact to Residual Soil Contamination Outside of the Operable Unit 5 Excavation Footprint

- The COC-specific soil PRLs were used to calculate source area-specific accumulated ILCR or HI levels due to the residual contamination of multiple COCs. The areas that have accumulated ILCR levels higher than $1x10^{-5}$ or HI values higher than 1.0 for the

undeveloped-park-user exposure scenario were identified. Additional remedial actions or source characterizations would need to be defined and incorporated into the RRA for these areas.

- An excavation volume of about 3000 cubic yards of surface soil from Source Area 582b was used because of high concentrations of COCs. This volume becomes a part of the additional excavation volume estimated for the Operable Unit 2 area (i.e., 20,000 cubic yards).

- The unexcavated portion of the original Source Area 570a as the new 570a-South source area was defined and the representative residual COC concentrations for 570a-South were recalculated. Most of the sampling data with higher COC concentrations than were used to calculate the original representative 570a concentrations were in the portion that would be excavated. The unexcavated 570a-South area has relatively lower contaminant concentrations than the excavated portion of 570a area.

- The inorganic COCs that have residual concentrations at the background levels were identified. The COCs (e.g., manganese) may still cause significant impacts; however, additional remedial actions cannot reduce these impacts.

- The COCs that have residual concentrations that are primarily controlled by the detection limits were identified. The COCs at the detection limit levels may cause significant impacts. However, the actual concentrations of these COCs may be much lower. These COCs may require further field investigation during the remedial actions so they can be eliminated from the postremedial COC list.

Actions Taken Based on Screening of Future Residual Source Loading Terms into the Great Miami Aquifer

- The storm water retention basins would be backfilled with at least 2.5 feet of clay at the end of FEMP remedial action.

- Statistically calculated block-by-block residual source concentrations for five major COCs in the groundwater pathway (i.e., magnesium, mercury, Sr-90, Tc-99, and uranium) were reviewed. These block-by-block concentrations were first used to determine the level of conservatism of the original area-wide representative source concentrations as defined in the Operable Unit 5 draft RI report. In the draft RI report, representative source concentrations were usually dominated by a few measured, higher concentrations in each area, which was delineated based on the distribution of uranium contamination. For other COCs, contamination may not be distributed as uniformly as uranium within each of these areas. Therefore, the RI representative concentrations may be too conservative for a large portion within some source areas. This situation is especially significant in source areas (e.g., 560a and 581a) along the border, where relatively few samples were used to represent large source areas.

  In the unexcavated areas where the extent of original RI source concentrations was determined to be overly conservative, the original area-wide source concentrations were replaced by the statistically calculated residual concentrations on a COC- and block-specific basis. These modifications result in more realistic COC distributions than were used in the

draft RI report for COCs other than uranium. However, they do not significantly change the maximum source concentrations and maximum mass loadings to the Great Miami Aquifer. Because these statistical analyses do not eliminate any sample data, the blocks which contain those measured, higher COC concentrations still remain in the analysis. The only significant impact of these modifications was the extent of the area which has higher residual concentrations in each source area. Thus, the areas of residual contamination become more realistic and COC-specific in the FS.

- The COCs that have residual concentrations that are primarily controlled by the detection limits were identified. The COCs (e.g., Tc-99) at the detection limit levels may cause significant impacts. However the actual concentrations of these COCs may be much lower. These COCs may require further field investigation during the remedial actions so they can be eliminated from the postremedial COC list.

Actions Taken Based on Screening of Residual Impacts in the Surface Water Pathway

- The NEb subbasin would be regraded as part of the construction for the on-site disposal area so that the surface runoff in this area will flow toward the site instead of immediately off-site.

- An excavation volume of about 3000 cubic yards of surface soil from Source Area 582b was used. This volume becomes a part of the additional excavation volume estimated for the Operable Unit 2 area (i.e., 20,000 cubic yards).

- An excavation volume of about 3000 cubic yards of surface soil from Source Area 582a was used to reduce magnesium source concentration. This become a part of the additional excavation volume estimated for the Operable Unit 2 area (i.e., 20,000 cubic yards).

- The inorganic COCs that have residual concentrations at the background levels were identified. The COCs (e.g., manganese) may still cause significant impacts; however, additional remedial actions cannot reduce these impacts.

H.I.2 Water Transport Models

Contaminant fate and transport models for surface water and groundwater pathways were used to predict future COC concentrations at receptor locations. The specific application of the models is demonstrated in Appendix F. A summary of these models is presented in Tables H.I-2 and H.I-3.

TABLE H.I-1
SCREENING RESULTS OF FUTURE IMPACTS FROM THE DISPOSAL CELL

COC	Disposal Cell WAC	Average Source Concentration		Maximum GMA Concentration	Maximum Fenceline Concentration	GMA Groundwater Criteria			
		Solid	Liquid			ILCR 10^{-6}	ILCR 10^{-5}	HQ=0.2	MCL
Organics	(mg/kg)	(mg/kg)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
Alpha-chlordane	$6.51 \times 10^{-2(a)}$	1.36×10^{-4}	4.07×10^{-2}	9.42×10^{-5}	8.46×10^{-5}	4.51×10^{-3}	4.51×10^{-2}	NA	2.00×10^{0}
Bis(2-chloroisopropyl)	$1.54 \times 10^{-2(a)}$	4.84×10^{-3}	6.92×10^{0}	5.13×10^{-1}	5.09×10^{-1}	1.63×10^{-1}	1.63×10^{0}	NA	NA
Bromodichloromethane	$2.24 \times 10^{-2(a)}$	2.32×10^{-3}	5.51×10^{0}	4.14×10^{-1}	4.12×10^{-1}	4.01×10^{-1}	4.01×10^{0}	NA	1.00×10^{2}
1,2-Dichloroethane	$1.34 \times 10^{5(a)}$	2.29×10^{-3}	1.47×10^{1}	1.34×10^{-8}	7.37×10^{-9}	7.86×10^{-2}	7.86×10^{-1}	NA	5.00×10^{0}
Carbazole	$7.27 \times 10^{4(a)}$	6.08×10^{-2}	5.63×10^{0}	9.54×10^{-6}	7.53×10^{-6}	1.14×10^{0}	1.14×10^{1}	NA	NA
Chromium(Hex)	$2.75 \times 10^{9(b)}$	3.12×10^{0}	8.43×10^{1}	2.52×10^{-8}	2.08×10^{-8}	NA	NA	2.22×10^{1}	NA
4-Nitroaniline	$2.72 \times 10^{-2(b)}$	2.78×10^{-4}	2.05×10^{0}	1.54×10^{-1}	1.52×10^{-1}	NA	NA	1.52×10^{1}	NA
Uranium - Total	$1.03 \times 10^{3(c,d)}$	1.00×10^{2}	6.67×10^{3}	1.93×10^{0}	1.62×10^{0}	2.57×10^{0}	2.57×10^{1}	1.77×10^{1}	2.00×10^{1}
Inorganics	(mg/kg)	(mg/kg)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
Boron	$1.04 \times 10^{3(b)}$	1.37×10^{1}	4.57×10^{3}	4.29×10^{0}	3.39×10^{0}	NA	NA	3.26×10^{2}	NA
Magnesium	$1.72 \times 10^{6(b)}$	2.64×10^{4}	5.87×10^{6}	5.39×10^{2}	3.71×10^{2}	NA	NA	3.52×10^{4}	NA
Mercury	$4.47 \times 10^{3(b)}$	5.44×10^{-1}	5.44×10^{1}	1.92×10^{-5}	8.31×10^{-6}	NA	NA	1.58×10^{-1}	2.00×10^{0}
Radionuclides	(pCi/g)	(pCi/g)	(pCi/L)	(pCi/L)	(pCi/L)	(pCi/L)	(pCi/L)	(pCi/L)	(pCi/L)
Np-237	$3.12 \times 10^{9(a)}$	1.02×10^{0}	1.86×10^{1}	2.57×10^{-10}	1.54×10^{-10}	7.83×10^{-2}	7.83×10^{-1}	NA	NA
Sr-90	$5.67 \times 10^{10(a)}$	3.79×10^{0}	3.79×10^{2}	2.07×10^{-10}	1.19×10^{-10}	3.09×10^{-1}	3.09×10^{0}	NA	NA
Tc-99	$2.91 \times 10^{1(a)}$	1.70×10^{0}	5.66×10^{1}	4.25×10^{0}	4.23×10^{0}	7.23×10^{0}	7.23×10^{1}	NA	NA
U-238	$3.45 \times 10^{2(c,d)}$	3.36×10^{1}	2.24×10^{3}	6.48×10^{-1}	5.44×10^{-1}	8.63×10^{-1}	8.63×10^{0}	5.94×10^{0}	NA

Notes: [a] Protective level: ILCR 10^{-5}
[b] Protective level: HQ of 0.2
[c] Protective level: MCL
[d] K_l = 15 L/kg
NA = Not Applicable
Area Size: 1000 feet by 1000 feet, 3-foot liner, infiltration rate: 0.89 inches/year
Gray Clay Thickness: 22 feet, constant source leachate concentration

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TABLE H.I-2

SURFACE WATER FLOW AND INFILTRATION MODELS

Model	Description and Use
HEC-1	HEC-1 is a computer model developed by the U.S. Army Corps of Engineers (USCOE 1990) to simulate rainfall and runoff. HEC-1 was used in this modeling effort to estimate the hydrologic parameters of the Paddys Run drainage basin which encompasses the FEMP. The output for HEC-1 was used as input for VS2DT, MUSLE, and the Partitioning Equations.
VS2DT	VS2DT is a computer model developed by the U.S. Geological Survey (USGS 1990) to simulate variably saturated groundwater flow in two dimensions. VS2DT was used in this modeling effort to estimate the amount and pattern of infiltration of surface water through the streambeds of Paddys Run and the SSOD.
MUSLE	The Modified Universal Soil Loss Equation presented in the Superfund Exposure Assessment Manual (EPA 1988) is used to estimate the amount of sediment which was generated by a single storm event. This equation was used in this modeling effort to estimate the amount of sediment generated by the representative storm event.
USLE	The Universal Soil Loss Equation presented in the Superfund Exposure Assessment Manual (EPA 1988) was used to estimate the annual amount of sediment produced in the subbasins of the Paddys Run drainage basin.
Partitioning Equations	The Partitioning Equations also are presented in the Superfund Exposure Assessment Manual. The partitioning equations consist of a series of equations used to determine the amount and concentration of contaminants released from the source surface soils in the dissolved phase (surface water) and the adsorbed phase (in sediments) from a single storm event.
SWF&IM	The Surface Water Flow and Infiltration Model is the term applied to collectively identify the above models used to simulate the rainfall, runoff, and Contaminant Transport. This is also sometimes referred to generically as the surface water model.

TABLE H.I-3

GROUNDWATER FATE AND TRANSPORT MODELS

Model	Description and Use
HELP	The HELP model was used in the OU5 analysis to define infiltration rates (seepage velocities) for use in travel time screening and in vadose zone modeling with ODAST. The HELP model (EPA 1984) is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of a waste area. The systems that can be modeled by HELP include various combinations of vegetation, cover soils, waste cells, special drainage layers, and relatively impermeable barrier soils.
ODAST	The ODAST model was used in the OU5 analysis to define vertical contaminant transport from contaminated soil or perched water to the GMA. The ODAST computer code is based on the solution originally developed by Ogata and Banks (1961) and calculates the normalized concentrations of a given constituent in a uniform flow field from a source having a constant or varying concentration in the initial layer. ODAST evaluates the basic one-dimensional analytical solute transport equation as a function of seepage velocity, dispersion coefficient, source decay, retardation factor, depletion time, and source rate.
ECTran	The ECTran model is a screening level groundwater contaminant fate and transport model implemented in Excel 4.0 which was developed to support the RI/FS processes at the FEMP. The Crystal Ball 3.0 add on module for Excel can be used with the ECTran model to perform Monte Carlo simulations. The ECTran model can be used to supplement other, more complex fate and transport models during parameter estimation, risk assessment, cleanup goal development, and stochastic sensitivity analysis. The model is based on straight-forward mass balances and advection/dispersion analytical equations, but can be used to simulate a variety of complex conditions.
SWIFT	The SWIFT Great Miami Aquifer model was used for simulating the three-dimensional contaminant transport in the Great Miami Aquifer. The SWIFT code is a fully coupled, transient, 3-dimensional finite difference model for groundwater flow through both porous and fractured media. The mass transport equations solved include terms for convection, dispersion, retardation by sorption, and decay or degradation of the contaminant. The SWIFT code, originally developed by Sandia National Laboratory in the late 1970s for the High Level Waste Program, has been revised several times to increase its capability and to change computer platforms. The SWIFT GMA model was originally calibrated in 1989. Recently the model has been redesigned and recalibrated based on new data.

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H.I.3 MODELING RESULTS

Surface Water

Tables H.I-4 and H.I-5 present the future surface water and sediment concentrations for all the modeled surface water COCs. Table H.I-6 presents the surface water contaminant loading to the Great Miami Aquifer of all of the COCs which account for 95 percent of the total risk and/or failed either the surface water or sediment screening as presented in Appendix F (Section F.2). The loadings from all of these COCs were calculated because they are required for the CRARE groundwater modeling. The computer print outs for the groundwater mass loading are presented at the end of this attachment.

Groundwater

The receptor locations modeled for the groundwater pathway are identified in the Operable Unit 5 draft RI report. The COC-specific maximum concentrations and the times of occurrence at each receptor location are listed in Tables H.I-7 and H.I-8 for on-property and off-property receptors, respectively. To estimate the accumulated impacts due to multiple COCs, COC-specific concentrations at the time of the uranium maximum at each receptor location are also determined. These results are listed in Table H.I-9.

The groundwater contamination plumes in the upper Great Miami Aquifer, following completion of groundwater recovery operations, at the time when the COC-specific maximum concentrations occur for each COC are shown in Figures H.I-1 through H.I-12. The residual contamination plumes of arsenice, manganese, and Ra-226 do not migrate significantly and remain relatively localized in the 1000-year period, as shown in Figures H.I-13 through H.I-15.

TABLE H.I-4

CRARE MODELING RESULTS, SURFACE WATER PATHWAY
SURFACE WATER CONCENTRATIONS

COCs	560	WPA	570	575	580	PDAR
Radionuclides (pCi/L)						
Radium-226+8d	0.00	0.00	0.00	0.00	0.00	8.31×10^{-3}
Strontium-90+1d	2.98×10^{0}	0.00	4.06×10^{-1}	3.37×10^{-1}	3.81×10^{-1}	5.12×10^{-2}
Technetium-99	1.33×10^{2}	0.00	0.00	0.00	0.00	0.00
Thorium-230	1.36×10^{-3}	0.00	6.54×10^{-3}	5.56×10^{-2}	0.00	0.00
Thorium-232+10d	0.00	0.00	0.00	0.00	0.00	0.00
Inorganics (μg/L)						
Antimony	3.74×10^{-1}	1.06×10^{-1}	9.64×10^{-2}	1.01×10^{-1}	9.48×10^{-2}	9.42×10^{-2}
Arsenic	1.86×10^{0}	9.69×10^{-1}	9.00×10^{-1}	1.12×10^{0}	1.01×10^{0}	8.79×10^{-1}
Beryllium	3.72×10^{-2}	1.61×10^{-2}	2.26×10^{-2}	3.67×10^{-2}	1.44×10^{-2}	1.82×10^{-2}
Magnesium	1.69×10^{5}	1.45×10^{4}	4.46×10^{4}	1.66×10^{5}	5.94×10^{4}	3.16×10^{4}
Manganese	1.64×10^{2}	1.58×10^{2}	1.27×10^{2}	2.29×10^{2}	7.67×10^{1}	1.61×10^{2}
Mercury	1.03×10^{0}	1.03×10^{0}	9.38×10^{-1}	9.78×10^{-1}	9.22×10^{-1}	9.16×10^{-1}
Uranium	1.69×10^{0}	0.00	4.82×10^{-1}	1.81×10^{0}	2.06×10^{-1}	1.74×10^{-1}
Organics (μg/L)						
Alpha-chlordane	0.00	0.00	0.00	0.00	0.00	3.36×10^{-3}
Aroclor-1254	0.00	0.00	0.00	0.00	0.00	0.00
Aroclor-1260	0.00	0.00	0.00	0.00	0.00	0.00
Benzo(a)pyrene	0.00	0.00	7.02×10^{-5}	2.93×10^{-4}	0.00	7.37×10^{-5}
Dibenzo(a,h)anthracene	0.00	0.00	0.00	0.00	0.00	0.00

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TABLE H.I-4
(Continued)

COC	581	582	NE	Max. Paddys Run	SSOD	GMR at Paddys Run
Radionuclides (pCi/L)						
Radium-226+8d	0.00	0.00	0.00	8.77×10^{-4}	1.45×10^{-3}	7.37×10^{-5}
Strontium-90+1d	0.00	3.01×10^{0}	2.78×10^{0}	8.84×10^{-1}	1.09×10^{0}	7.43×10^{-2}
Technetium-99	0.00	0.00	0.00	2.65×10^{1}	0.00	2.23×10^{0}
Thorium-230	0.00	8.62×10^{-3}	0.00	1.46×10^{-2}	3.06×10^{-3}	1.23×10^{-3}
Thorium-232+10d	0.00	4.68×10^{-4}	1.77×10^{-4}	1.00×10^{-4}	1.66×10^{-4}	8.44×10^{-6}
Inorganics (μg/L)						
Antimony	1.07×10^{-1}	1.05×10^{-1}	1.05×10^{-1}	1.01×10^{-1}	1.04×10^{-1}	8.48×10^{-3}
Arsenic	9.79×10^{-1}	1.47×10^{0}	1.00×10^{0}	1.04×10^{0}	1.14×10^{0}	8.72×10^{-2}
Beryllium	1.63×10^{-2}	3.68×10^{-2}	1.82×10^{-2}	2.23×10^{-2}	2.38×10^{-2}	1.87×10^{-3}
Magnesium	1.46×10^{4}	1.42×10^{4}	1.71×10^{4}	5.01×10^{4}	1.92×10^{4}	4.21×10^{3}
Manganese	1.59×10^{2}	1.19×10^{2}	1.85×10^{2}	1.37×10^{2}	1.42×10^{2}	1.15×10^{1}
Mercury	1.04×10^{0}	1.02×10^{0}	1.02×10^{0}	9.73×10^{-1}	1.01×10^{0}	8.18×10^{-2}
Uranium	0.00	1.31×10^{0}	9.48×10^{-1}	5.32×10^{-1}	5.04×10^{-1}	4.47×10^{-2}
Organics (μg/L)						
Alpha-chlordane	0.00	0.00	0.00	3.54×10^{-4}	5.86×10^{-4}	2.98×10^{-5}
Aroclor-1254	0.00	0.00	0.00	0.00	0.00	0.00
Aroclor-1260	0.00	0.00	0.00	0.00	0.00	0.00
Benzo(a)pyrene	0.00	0.00	0.00	8.42×10^{-5}	1.29×10^{-5}	7.08×10^{-6}
Dibenzo(a,h)anthracene	0.00	0.00	0.00	0.00	0.00	0.00

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TABLE H.I-5

CRARE MODELING RESULTS, SURFACE WATER PATHWAY SEDIMENT CONCENTRATIONS

COCs	560	WPA	570	575	580	PDAR
Radionuclides (pCi/L)						
Radium-226+8d	0.00	0.00	0.00	0.00	0.00	1.87×10^{-1}
Strontium-90+1d	8.58×10^{-1}	0.00	1.28×10^{-1}	1.02×10^{-1}	1.22×10^{-1}	1.65×10^{-2}
Technetium-99	4.50×10^{-1}	0.00	0.00	0.00	0.00	0.00
Thorium-230	2.27×10^{-1}	0.00	1.19×10^{0}	9.75×10^{0}	0.00	0.00
Thorium-232+10d	0.00	0.00	0.00	0.00	0.00	0.00
Inorganics (μg/L)						
Antimony	2.69×10^{0}	7.60×10^{-1}	7.60×10^{-1}	7.60×10^{-1}	7.60×10^{-1}	7.60×10^{-1}
Arsenic	1.07×10^{1}	5.56×10^{0}	5.67×10^{0}	6.76×10^{0}	6.50×10^{0}	5.67×10^{0}
Beryllium	1.39×10^{0}	6.00×10^{-1}	9.25×10^{-1}	1.44×10^{0}	6.00×10^{-1}	7.62×10^{-1}
Magnesium	2.19×10^{4}	1.87×10^{3}	6.33×10^{3}	2.25×10^{4}	8.57×10^{3}	4.59×10^{3}
Manganese	8.52×10^{2}	8.13×10^{2}	7.21×10^{2}	1.25×10^{3}	4.43×10^{2}	9.36×10^{2}
Uranium	1.58×10^{1}	0.00	4.94×10^{0}	1.77×10^{1}	2.14×10^{0}	1.82×10^{0}
Organics (μg/L)						
Alpha-chlordane	0.00	0.00	0.00	0.00	0.00	3.62×10^{-4}
Aroclor-1254	0.00	0.00	0.00	0.00	0.00	0.00
Aroclor-1260	0.00	0.00	0.00	0.00	0.00	0.00
Benzo(a)pyrene	0.00	0.00	1.17×10^{-2}	4.68×10^{-2}	0.00	1.26×10^{-2}
Dibenzo(a,h)anthracene	0.00	0.00	0.00	0.00	0.00	0.00

000151

TABLE H.I-5
(Continued)

Constituents of Concern	581	582	NE	Max. Paddys Run	SSOD	GMR at Paddys Run
Radionuclides (pCi)						
Radium-226+8d	0.00	0.00	0.00	1.97×10^{-2}	3.26×10^{-2}	1.65×10^{-3}
Strontium-90+1d	0.00	8.72×10^{-1}	8.01×10^{-1}	2.56×10^{-1}	3.17×10^{-1}	2.15×10^{-2}
Technetium-99	0.00	0.00	0.00	9.01×10^{-2}	0.00	7.57×10^{-3}
Thorium-230	0.00	1.45×10^{0}	0.00	2.57×10^{0}	5.14×10^{-1}	2.16×10^{-1}
Thorium-232+10d	0.00	7.87×10^{-2}	2.97×10^{-2}	1.69×10^{-2}	2.79×10^{-2}	1.42×10^{-3}
Inorganics (μg/L)						
Antimony	7.60×10^{-1}	7.60×10^{-1}	7.60×10^{-1}	7.73×10^{-1}	7.60×10^{-1}	6.50×10^{-2}
Arsenic	5.56×10^{0}	8.53×10^{0}	5.79×10^{0}	6.17×10^{0}	6.67×10^{0}	5.19×10^{-1}
Beryllium	6.00×10^{-1}	1.39×10^{0}	6.84×10^{-1}	8.66×10^{-1}	9.07×10^{-1}	7.28×10^{-2}
Magnesium	1.87×10^{3}	1.85×10^{3}	2.22×10^{3}	6.85×10^{3}	2.61×10^{3}	5.76×10^{2}
Manganese	8.13×10^{2}	6.22×10^{2}	9.63×10^{2}	7.50×10^{2}	7.52×10^{2}	6.30×10^{1}
Uranium	0.00	1.23×10^{1}	8.90×10^{0}	5.27×10^{0}	4.78×10^{0}	4.43×10^{-1}
Organics (μg/L)						
Alpha-chlordane	0.00	0.00	0.00	3.81×10^{-5}	6.32×10^{-5}	3.21×10^{-6}
Aroclor-1254	0.00	0.00	0.00	0.00	0.00	0.00
Aroclor-1260	0.00	0.00	0.00	0.00	0.00	0.00
Benzo(a)pyrene	0.00	0.00	0.00	1.36×10^{-2}	2.20×10^{-3}	1.14×10^{-3}
Dibenzo(a,h)anthracene	0.00	0.00	0.00	0.00	0.00	0.00

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TABLE H.I-6

SURFACE WATER PATHWAY LOADINGS TO THE GREAT MIAMI AQUIFER

COC	CD[a] (kg/yr)	DE[a] (kg/yr)	EF[a] (kg/yr)	SSOD (kg/yr)
Radionuclides				
Radium-226+8D	0.00	0.00	2.50×10^{-11}	1.12×10^{-9}
Strontium-90+1D	3.37×10^{-9}	1.38×10^{-9}	2.46×10^{-10}	5.89×10^{-9}
Technetium-99	1.14×10^{-3}	4.16×10^{-4}	3.33×10^{-5}	0.00
Thorium-230	2.89×10^{-8}	1.60×10^{-7}	1.46×10^{-8}	1.10×10^{-7}
Thorium-232+10D	0.00	0.00	2.51×10^{-5}	1.12×10^{-3}
Inorganics				
Antimony	6.31×10^{-2}	2.92×10^{-2}	3.95×10^{-3}	6.41×10^{-2}
Arsenic	3.50×10^{-1}	1.95×10^{-1}	3.35×10^{-2}	7.27×10^{-1}
Beryllium	7.20×10^{-3}	4.77×10^{-3}	7.65×10^{-4}	1.58×10^{-2}
Magnesium	2.78×10^{4}	1.94×10^{4}	1.84×10^{3}	1.21×10^{4}
Manganese	3.55×10^{1}	2.64×10^{1}	4.27×10^{0}	8.73×10^{1}
Mercury	2.31×10^{-1}	1.44×10^{-1}	2.73×10^{-2}	6.23×10^{-1}
Uranium	2.77×10^{-1}	2.02×10^{-1}	2.45×10^{-2}	3.73×10^{-1}
Organics				
Alpha-chlordane	0.00	0.00	9.98×10^{-6}	4.46×10^{-4}
Aroclor-1254	0.00	0.00	0.00	0.00
Aroclor-1260	0.00	0.00	0.00	0.00
Benzo(a)pyrene	4.24×10^{-6}	1.79×10^{-5}	1.64×10^{-6}	9.80×10^{-6}
Dibenzo(a,h)anthracene	0.00	0.00	0.00	0.00

[a] Operable Unit 5 RI (Appendix F) presents the description of Paddys Run reaches
SSOD - Storm Sewer Outfall Ditch

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TABLE H.I-7

SUMMARY OF TIME, LOCATION, AND MAXIMUM GROUNDWATER CONCENTRATIONS OF COCs AT ON-PROPERTY LOCATIONS

COC	On-Site Maximum			On-Site Fenceline Maximum		
	Concentration (μg/L)	Time (yr)	Grid Location (I,J)	Concentration (μg/L)	Time (yr)	Grid Location (I,J)
Radionuclides						
Np-237	1.131×10^{-4}	0	46,80	9.716×10^{-6}	100	34,47
Ra-226	1.207×10^{-5}	0	30,84	1.382×10^{-6}	450	65,60
Sr-90	2.999×10^{-8}	140	47,55	6.545×10^{-9}	190	26,50
Tc-99	4.892×10^{-3}	40	28,68	1.261×10^{-3}	60	32,47
Inorganics						
Antimony	4.591×10^{-1}	1000	47,55	1.712×10^{-1}	1000	34,47
Arsenic	9.635×10^{1}	0	61,71	7.184×10^{1}	0	49,108
Boron	2.823×10^{2}	520	75,92	2.018×10^{2}	480	62,100
Magnesium	1.476×10^{5}	240	34,64	6.159×10^{4}	350	34,47
Manganese	1.054×10^{4}	0	23,14	4.089×10^{2}	0	73,73
Mercury	4.282×10^{0}	630	47,55	1.254×10^{0}	800	34,47
Uranium-Total	2.159×10^{1}	670	77,91	2.138×10^{1}	510	76,76
Organics						
Alpha-chlordane	2.467×10^{-2}	120	50,64	4.621×10^{-3}	140	61,53

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TABLE H.I-7
(Continued)

COC	East Boundary Concentration (μg/L)	Time (yr)	Grid Location (I,J)	West Boundary Concentration (μg/L)	Time (yr)	Grid Location (I,J)	North Boundary Concentration (μg/L)	Time (Yr)	Grid Location (I,J)
Radionuclides									
Np-237	2.694×10^{-6}	330	56,44	2.229×10^{-5}	0	22,70	1.730×10^{-11}	260	62,100
Ra-226	1.382×10^{-6}	450	65,60	1.193×10^{-6}	0	31,101	1.045×10^{-6}	0	46,110
Sr-90	8.440×10^{-10}	70	58,47	2.385×10^{-9}	170	22,69	3.719×10^{-17}	310	62,100
Tc-99	7.546×10^{-4}	30	57,46	1.056×10^{-3}	40	22,69	4.564×10^{-4}	50	62,100
Inorganics									
Antimony	8.263×10^{-2}	1000	54,40	5.842×10^{-2}	250	22,69	5.181×10^{-6}	50	62,100
Arsenic	3.019×10^{0}	300	69,66	3.252×10^{-1}	1000	22,69	7.184×10^{1}	0	49,108
Boron	9.577×10^{1}	610	84,88	4.750×10^{0}	290	22,70	2.018×10^{2}	480	62,100
Magnesium	3.223×10^{4}	530	54,40	2.583×10^{4}	300	22,69	3.254×10^{4}	720	62,100
Manganese	4.089×10^{2}	0	73,73	1.479×10^{2}	50	28,89	1.657×10^{0}	1000	61,99
Mercury	6.840×10^{-1}	1000	54,40	2.145×10^{-1}	710	22,69	3.445×10^{-3}	1000	55,105
Uranium-Total	2.124×10^{1}	520	75,75	1.797×10^{0}	0	26,84	7.934×10^{0}	640	62,100
Organics									
Alpha-chlordane	4.621×10^{-3}	140	61,53	1.453×10^{-9}	90	21,65	8.612×10^{-13}	150	62,100

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TABLE H.I-8

SUMMARY OF TIME, LOCATION, AND MAXIMUM GROUNDWATER CONCENTRATIONS OF COCs AT OFF-PROPERTY RECEPTOR LOCATIONS

Receptor Location:	Well 12 (28,46,1)		Well 12 (28,46,2)		Well 13 (39,44,1)		Well 13 (59,38,1)	
COC	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time
Radionuclides								
Np-237	4.10×10^{-6}	80	5.06×10^{-6}	90	8.00×10^{-6}	160	1.84×10^{-6}	430
Ra-226	2.20×10^{-7}	1000	1.00×10^{-7}	1000	1.40×10^{-9}	1000	1.10×10^{-8}	1000
Sr-90	4.56×10^{-9}	140	2.31×10^{-9}	150	2.60×10^{-9}	160	1.19×10^{-10}	210
Tc-99	9.95×10^{-4}	40	1.19×10^{-3}	40	1.04×10^{-3}	40	5.00×10^{-4}	40
Inorganics								
Antimony	1.32×10^{-1}	200	1.11×10^{-1}	300	1.47×10^{-1}	300	5.88×10^{-2}	650
Arsenic	1.07×10^{0}	0	5.92×10^{-1}	0	4.75×10^{-2}	200	1.21×10^{-2}	1000
Boron	1.26×10^{1}	40	5.90×10^{0}	50	9.81×10^{1}	170	3.63×10^{1}	350
Magnesium	4.99×10^{4}	380	4.97×10^{4}	990	5.58×10^{4}	370	2.09×10^{4}	600
Manganese	6.53×10^{1}	100	7.56×10^{1}	150	9.79×10^{1}	600	6.21×10^{0}	1000
Mercury	9.48×10^{-1}	970	6.78×10^{-1}	990	1.32×10^{0}	660	3.94×10^{-1}	1000
Uranium-Total	1.82×10^{0}	0	2.47×10^{0}	0	9.02×10^{0}	20	7.44×10^{0}	430
Organics								
Alpha-Chlordane	4.77×10^{-4}	60	2.50×10^{-4}	70	7.99×10^{-4}	90	2.01×10^{-3}	150

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TABLE H.I-8
(Continued)

Receptor Location:	Well 34		Well 2071		Well 2119		Well 2127	
	(5,11,1)		(85,66,1)		(73,52,1)		(5,6,1)	
COC	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time
Radionuclides								
Np-237	4.39×10^{-6}	0	8.95×10^{-8}	450	7.32×10^{-7}	450	6.53×10^{-6}	0
Ra-226	1.50×10^{-9}	1000	1.10×10^{-25}	1000	1.00×10^{-6}	0	2.0×10^{-8}	1000
Sr-90	2.48×10^{-13}	290	9.34×10^{-12}	90	4.83×10^{-12}	260	2.34×10^{-12}	310
Tc-99	1.36×10^{-6}	80	1.04×10^{-4}	60	2.07×10^{-4}	40	1.43×10^{-5}	80
Uranium-Total	7.92×10^{-2}	0	5.61×10^{0}	600	4.00×10^{0}	410	3.52×10^{-1}	0
Inorganics								
Antimony	1.37×10^{-4}	500	1.47×10^{-3}	100	1.12×10^{-2}	100	1.43×10^{-3}	550
Arsenic	4.49×10^{-1}	50	4.58×10^{-1}	850	2.69×10^{-1}	1000	3.47×10^{0}	50
Boron	6.33×10^{-3}	410	1.06×10^{1}	700	1.64×10^{1}	340	7.33×10^{-2}	410
Magnesium	5.78×10^{1}	1000	3.64×10^{3}	990	8.61×10^{3}	530	6.02×10^{2}	1000
Manganese	2.22×10^{0}	850	1.66×10^{1}	1000	1.08×10^{1}	1000	1.90×10^{1}	800
Mercury	6.92×10^{-4}	1000	4.03×10^{-3}	1000	5.71×10^{-2}	1000	7.11×10^{-3}	1000
Organics								
Alpha-Chlordane	4.00×10^{-7}	190	4.35×10^{-5}	170	1.50×10^{-3}	160	4.31×10^{-6}	190

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TABLE H.I-8
(Continued)

Receptor Location:	FEMP Production Well		FEMP Production Well		SOWC Coll 1		SOWC Coll 1	
	(43,75,1)		(43,75,5)		(101,38,1)		(101,38,5)	
COC	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time
Radionuclides								
Np-237	6.79×10^{-6}	40	7.66×10^{-7}	160	1.48×10^{-8}	870	2.18×10^{-8}	880
Ra-226	6.00×10^{-10}	1000	6.70×10^{-12}	1000	3.50×10^{-32}	1000	3.70×10^{-32}	1000
Sr-90	2.02×10^{-10}	170	9.93×10^{-12}	240	3.73×10^{-15}	420	5.36×10^{-15}	420
Tc-99	3.41×10^{-4}	30	8.10×10^{-5}	30	6.60×10^{-6}	70	9.87×10^{-6}	70
Inorganics								
Antimony	6.68×10^{-2}	0	1.86×10^{-2}	0	5.30×10^{-4}	800	7.99×10^{-4}	850
Arsenic	1.01×10^{-2}	250	9.90×10^{-3}	1000	5.38×10^{-5}	1000	8.60×10^{-5}	1000
Boron	6.83×10^{0}	180	4.90×10^{-1}	630	2.94×10^{-1}	580	4.33×10^{-1}	580
Magnesium	1.06×10^{4}	260	2.07×10^{3}	970	1.81×10^{2}	1000	2.66×10^{2}	1000
Manganese	6.05×10^{1}	800	1.95×10^{2}	0	8.73×10^{-1}	100	1.21×10^{0}	100
Mercury	7.14×10^{-2}	610	1.54×10^{-2}	1000	1.01×10^{-4}	1000	1.44×10^{-4}	1000
Uranium-Total	5.79×10^{0}	0	2.91×10^{0}	30	9.48×10^{-2}	590	1.41×10^{-1}	590
Organics								
Alpha-Chlordane	5.95×10^{-6}	110	1.23×10^{-7}	130	3.60×10^{-5}	220	5.32×10^{-5}	220

000158

TABLE H.I-8
(Continued)

Receptor Location:	SOWC Coll 2		SOWC Coll 2		Strickers Grove Well		N.E. Recept.	
	(108,52,1)		(108,52,5)		(87,44,1)		(90,91,1)	
COC	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time	Conc. (μg/L)	Time
Radionuclides								
Np-237	8.19×10^{-8}	660	1.14×10^{-7}	670	3.06×10^{-7}	820	1.07×10^{-10}	710
Ra-226	6.80×10^{-30}	1000	1.20×10^{-29}	1000	1.80×10^{-24}	1000	4.50×10^{-35}	1000
Sr-90	1.53×10^{-13}	160	1.82×10^{-13}	160	1.38×10^{-13}	380	3.71×10^{-18}	370
Tc-99	5.58×10^{-5}	70	7.66×10^{-5}	80	1.26×10^{-4}	70	1.23×10^{-4}	60
Inorganics								
Antimony	1.58×10^{-3}	150	2.19×10^{-3}	150	9.90×10^{-3}	900	1.68×10^{-5}	150
Arsenic	8.13×10^{-2}	1000	1.10×10^{-1}	1000	3.32×10^{-4}	1000	2.57×10^{-3}	1000
Boron	5.36×10^{0}	850	7.36×10^{0}	850	6.12×10^{0}	550	3.48×10^{1}	670
Magnesium	1.35×10^{3}	1000	1.85×10^{3}	1000	3.76×10^{3}	1000	4.49×10^{3}	1000
Manganese	5.51×10^{0}	150	8.10×10^{0}	150	2.34×10^{-1}	1000	2.67×10^{-2}	1000
Mercury	9.75×10^{-4}	1000	1.29×10^{-3}	1000	3.93×10^{-3}	1000	2.80×10^{-4}	1000
Uranium-Total	1.73×10^{0}	770	2.33×10^{0}	780	1.85×10^{0}	560	4.45×10^{0}	790
Organics								
Alpha-Chlordane	1.50×10^{-4}	200	2.10×10^{-4}	200	7.21×10^{-4}	210	1.62×10^{-8}	1000

000159

TABLE H.I-9
GROUNDWATER RECEPTOR CONCENTRATIONS AT TIME OF MAXIMUM CONCENTRATION OF TOTAL URANIUM

Receptor Location:	Well 12	Well 12	Well 13	Well 14	Well 34	Well 2071	Well 2119	Well 2127
(Grid)	(28,46,1)	(28,46,2)	(39,44,1)	(59,38,1)	(5,11,1)	(85,66,1)	(73,52,1)	(5,6,1)
Time (year):	0	0	20	430	0	600	410	0
COC								
Radionuclides (μg/L)								
Np-237	2.180×10^{-6}	1.390×10^{-6}	1.022×10^{-7}	1.837×10^{-6}	4.390×10^{-6}	5.477×10^{-8}	6.939×10^{-7}	6.530×10^{-6}
Ra-226	6.090×10^{-15}	7.510×10^{-16}	4.324×10^{-17}	3.942×10^{-9}	0.00	0.00	7.671×10^{-7}	0.00
Sr-90	0.00	0.00	2.065×10^{-10}	1.180×10^{-10}	0.00	3.911×10^{-14}	4.756×10^{-12}	0.00
Tc-99	2.100×10^{-6}	2.470×10^{-6}	9.850×10^{-4}	3.890×10^{-4}	1.110×10^{-7}	2.460×10^{-5}	1.465×10^{-4}	9.010×10^{-7}
Inorganics (μg/L)								
Antimony	3.430×10^{-3}	4.030×10^{-3}	4.781×10^{-2}	5.874×10^{-2}	8.080×10^{-5}	6.927×10^{-4}	1.079×10^{-2}	4.060×10^{-4}
Arsenic	1.070×10^{0}	5.920×10^{-1}	1.560×10^{-6}	2.082×10^{-3}	7.450×10^{-2}	2.686×10^{-1}	1.265×10^{-2}	1.050×10^{0}
Boron	0.00	0.00	6.300×10^{-1}	2.453×10^{1}	0.00	9.496×10^{0}	1.087×10^{1}	0.00
Magnesium	0.00	0.00	6.690×10^{0}	1.395×10^{4}	0.00	1.052×10^{3}	5.144×10^{3}	0.00
Manganese	2.250×10^{1}	5.050×10^{1}	6.420×10^{1}	3.332×10^{0}	1.660×10^{-10}	6.378×10^{0}	3.367×10^{-1}	1.610×10^{-8}
Mercury	0.00	0.00	2.656×10^{-7}	8.786×10^{-2}	0.00	1.992×10^{-3}	2.461×10^{-3}	0.00
Uranium-Total	1.820×10^{0}	2.740×10^{0}	9.020×10^{0}	7.442×10^{0}	7.920×10^{-2}	5.606×10^{0}	3.998×10^{0}	3.520×10^{-1}
Organics (μg/L)								
Alpha-Chlordane	0.00	0.00	5.192×10^{-4}	2.594×10^{-4}	0.00	6.710×10^{-8}	2.158×10^{-5}	0.00

000130

TABLE H.I-9
(Continued)

Receptor Location: (Grid)	FEMP Production Well (43,75,1)	FEMP Production Well (43,75,5)	SOWC Coll 1 (101,38,1)	SOWC Coll 1 (101,38,5)	SOWC Coll 2 (108,52,1)	SOWC Coll 2 (108,52,5)	Strickers Grove Well (87,44,1)	NE Recept. (90,91,1)
Time (Years):	0	30	590	590	770	780	560	790
COC								
Radionuclides (μg/L)								
Np-237	5.790×10^{0}	2.592×10^{-8}	4.054×10^{-9}	5.760×10^{-9}	7.000×10^{-8}	9.598×10^{-8}	9.026×10^{-8}	9.868×10^{-11}
Ra-226	0.00	1.393×10^{-17}	0.00	0.00	0.00	0.00	0.00	0.00
Sr-90	0.00	1.185×10^{-14}	3.710×10^{-15}	5.334×10^{-15}	1.894×10^{-14}	2.609×10^{-14}	1.371×10^{-13}	2.358×10^{-18}
Tc-99	2.020×10^{-5}	8.100×10^{-5}	5.399×10^{-6}	8.081×10^{-6}	2.400×10^{-5}	3.338×10^{-5}	1.027×10^{-4}	5.843×10^{-6}
Inorganics (μg/L)								
Antimony	6.680×10^{-2}	1.246×10^{-2}	5.287×10^{-4}	7.969×10^{-4}	1.387×10^{-3}	1.952×10^{-3}	9.884×10^{-3}	8.334×10^{-7}
Arsenic	3.670×10^{-8}	1.590×10^{-9}	1.373×10^{-7}	2.433×10^{-7}	1.354×10^{-2}	2.003×10^{-2}	6.316×10^{-8}	1.139×10^{-4}
Boron	0.00	3.586×10^{-6}	2.930×10^{-1}	4.325×10^{-1}	4.678×10^{0}	6.588×10^{0}	6.097×10^{0}	2.024×10^{1}
Magnesium	0.00	2.475×10^{-5}	1.944×10^{1}	2.768×10^{1}	9.383×10^{2}	1.303×10^{3}	4.198×10^{2}	8.661×10^{2}
Manganese	6.290×10^{-2}	1.793×10^{2}	1.548×10^{-2}	2.219×10^{-2}	1.027×10^{-1}	1.257×10^{-1}	1.815×10^{-2}	3.414×10^{-3}
Mercury	0.00	3.706×10^{-15}	4.550×10^{-7}	6.516×10^{-7}	2.788×10^{-4}	3.703×10^{-4}	1.926×10^{-5}	6.914×10^{-5}
Uranium-Total	5.790×10^{0}	2.910×10^{0}	9.478×10^{-2}	1.409×10^{-1}	1.731×10^{0}	2.325×10^{0}	1.853×10^{0}	4.453×10^{0}
Organics (μg/L)								
Alpha-Chlordane	0.00	4.176×10^{-10}	1.604×10^{-6}	2.440×10^{-6}	1.964×10^{-6}	2.805×10^{-6}	2.929×10^{-5}	5.937×10^{-10}

000161

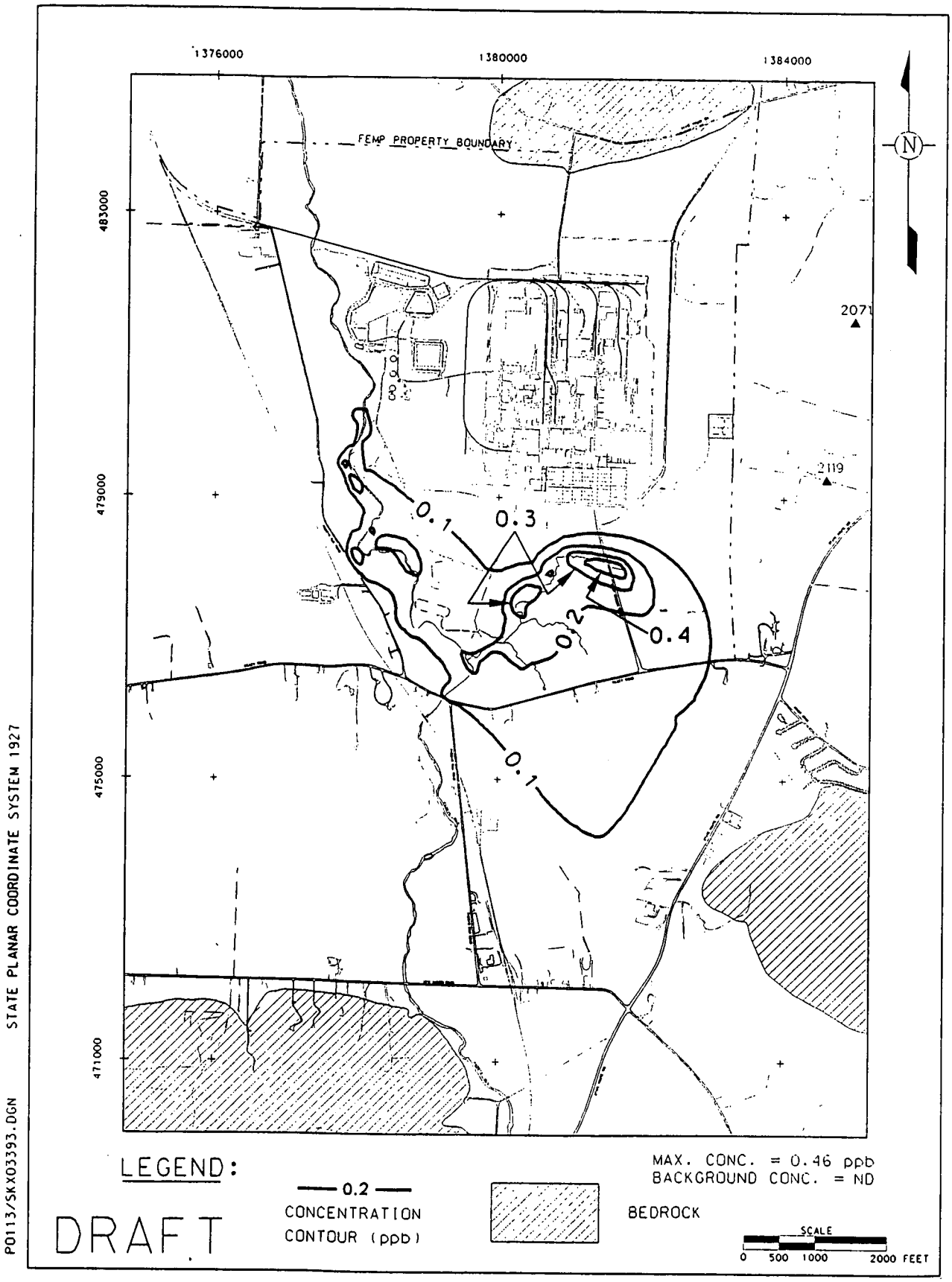

FIGURE H.1-1. ANTIMONY MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 1000

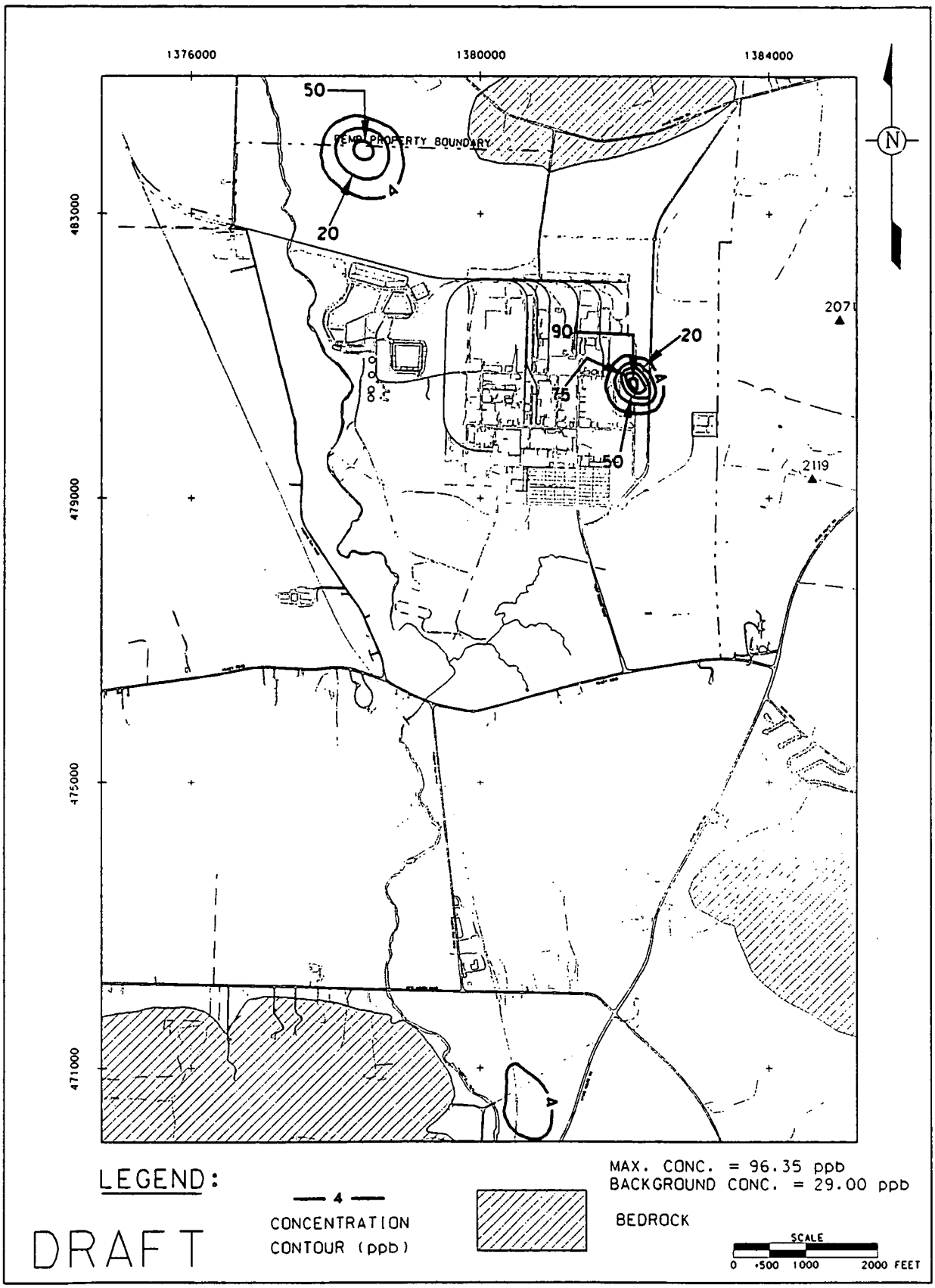

FIGURE H.I-2. ARSENIC MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 0

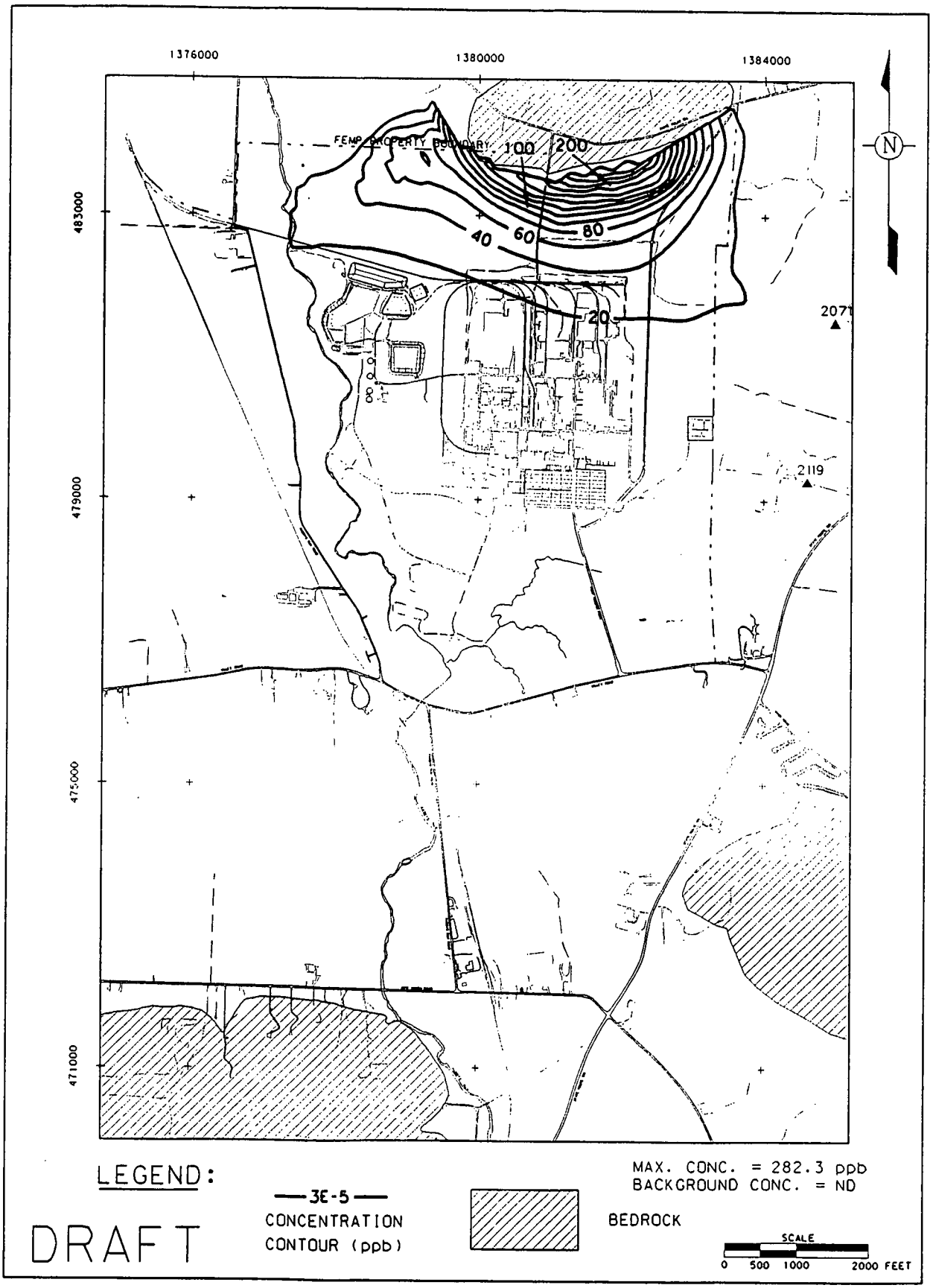

FIGURE H.1-3. BORON MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 520

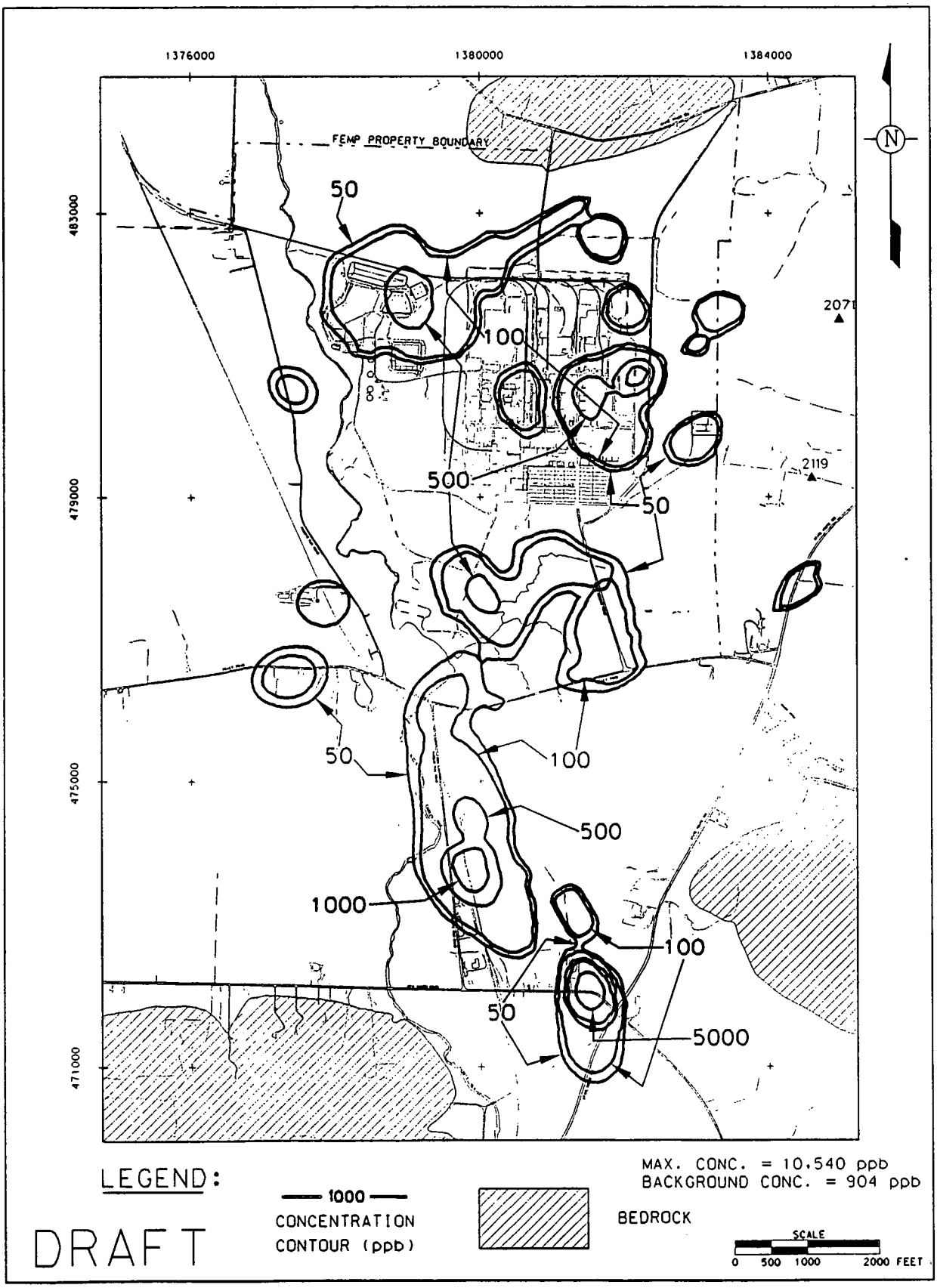

FIGURE H.I-4. MANGANESE MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 0

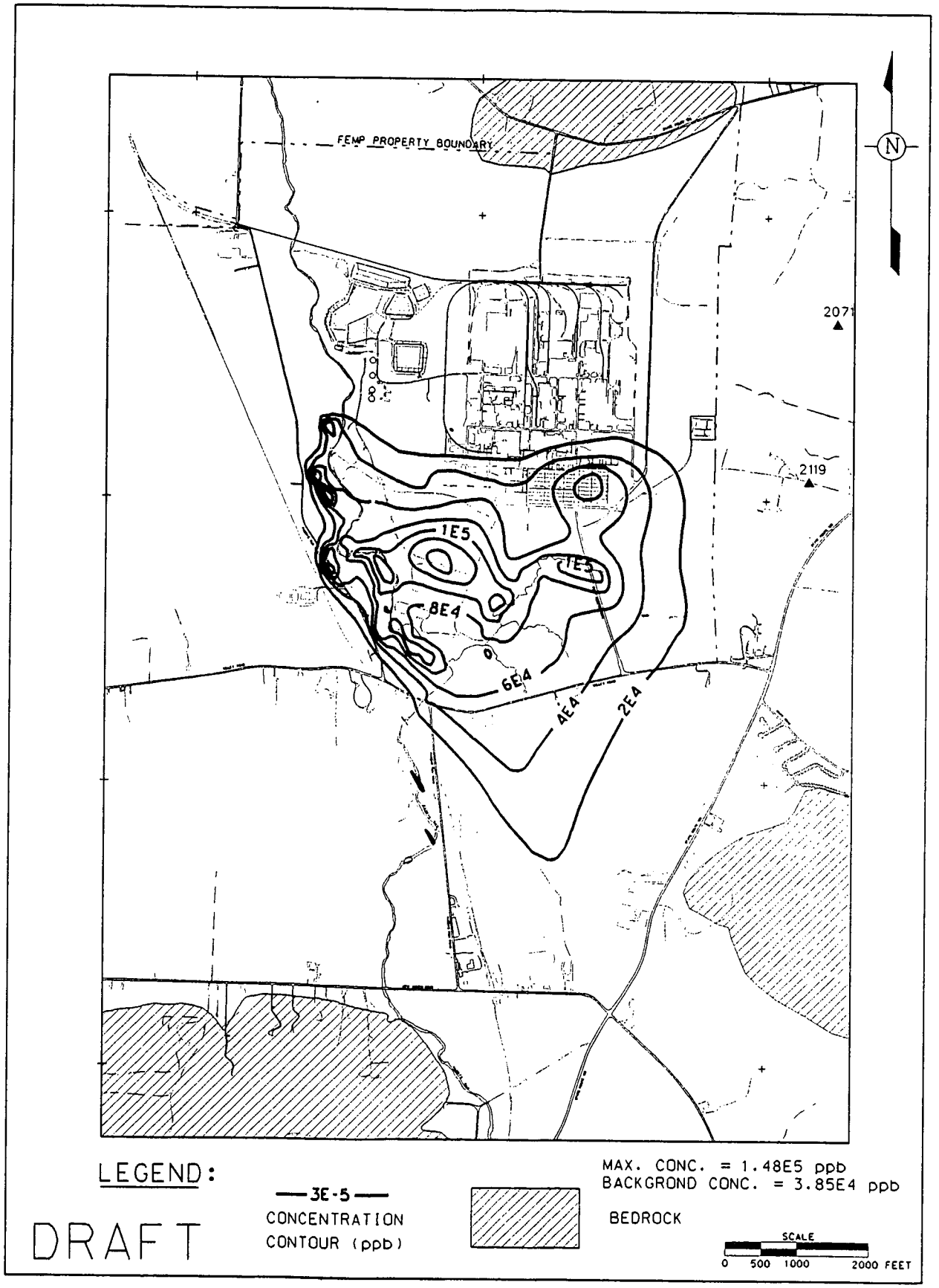

FIGURE H.1-5. MAGNESIUM MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 240

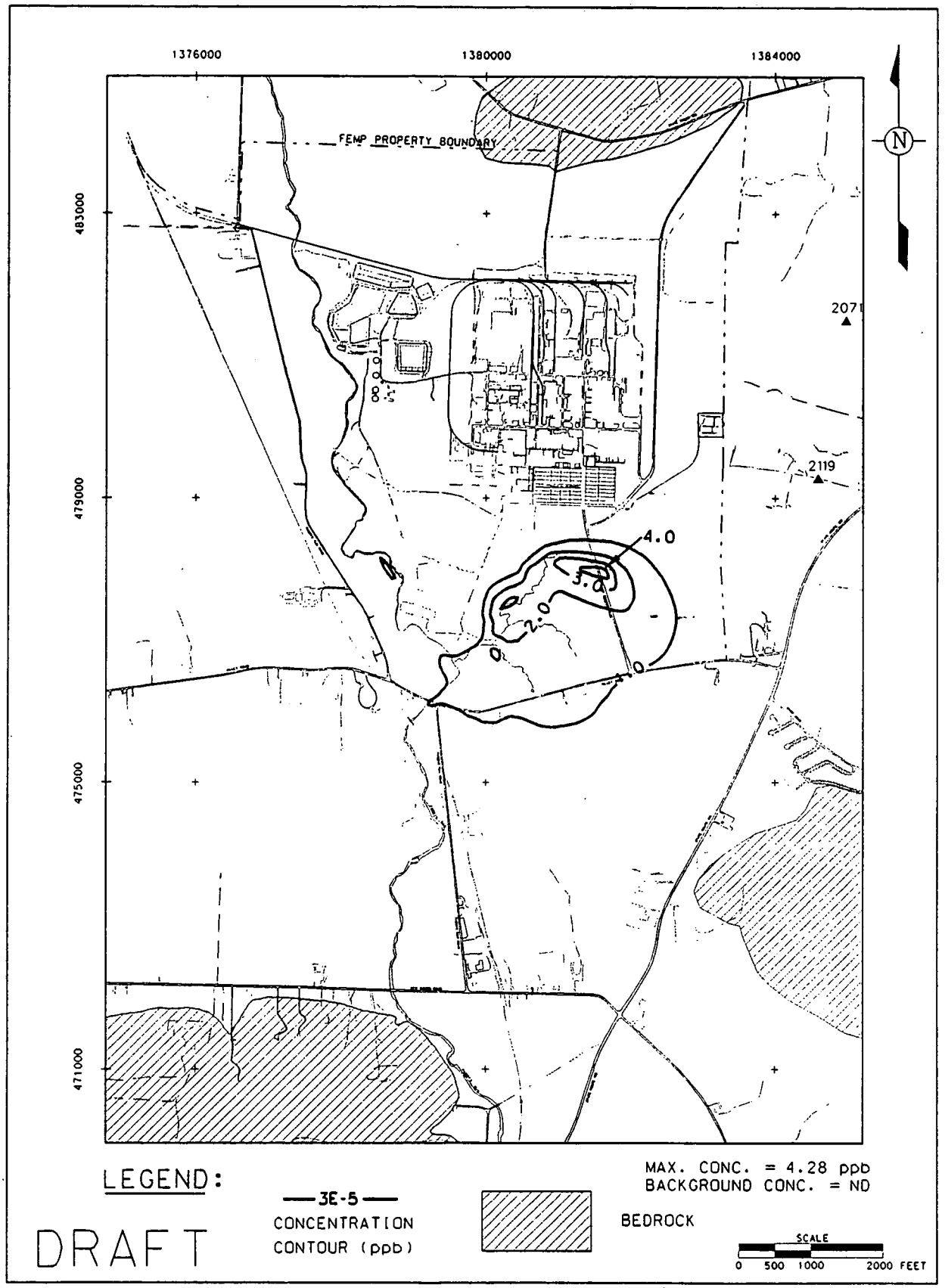

FIGURE H.I-6. MERCURY MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 630

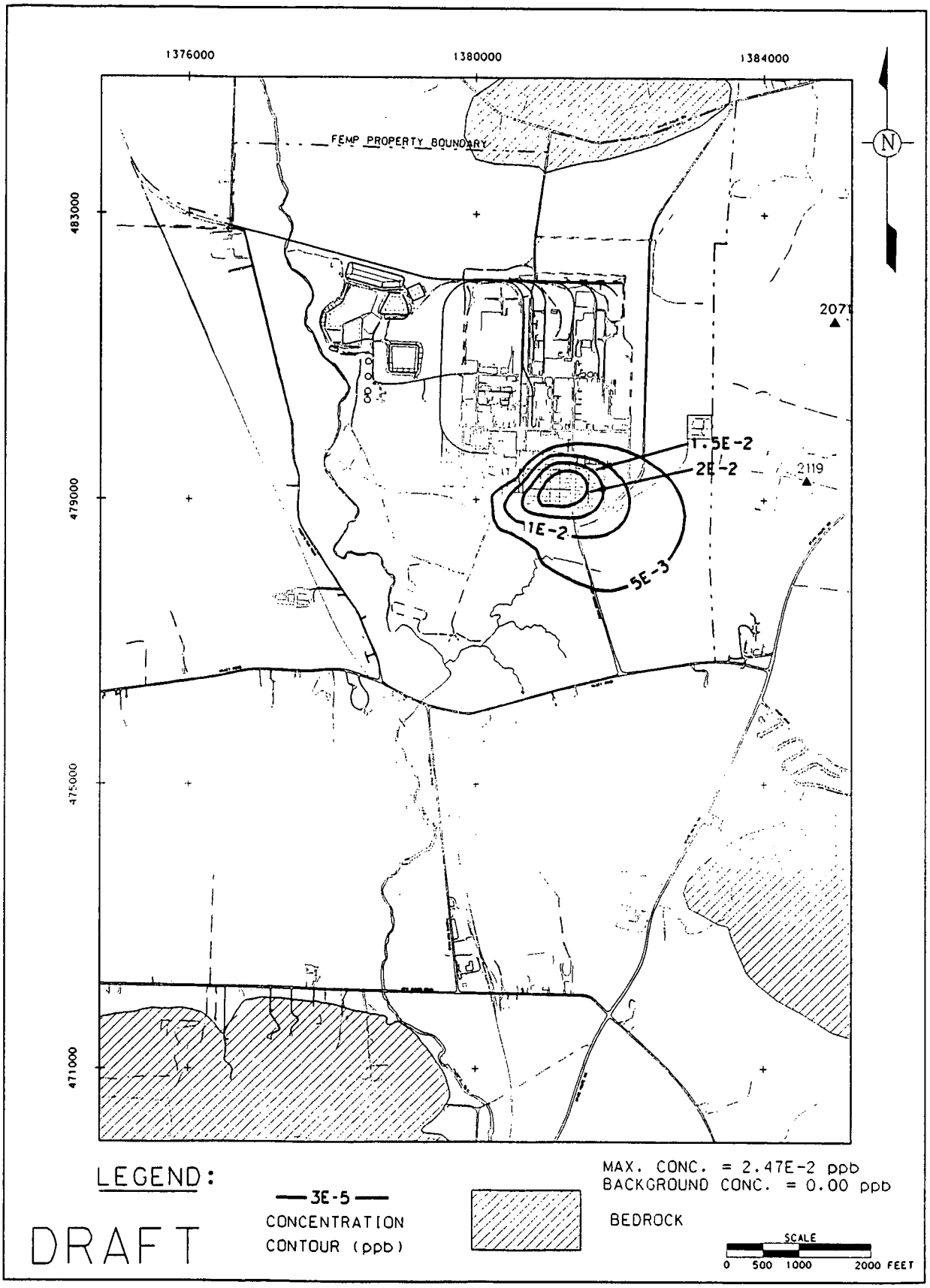

FIGURE H.I-7. ALPHA-CHLORDANE MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 120

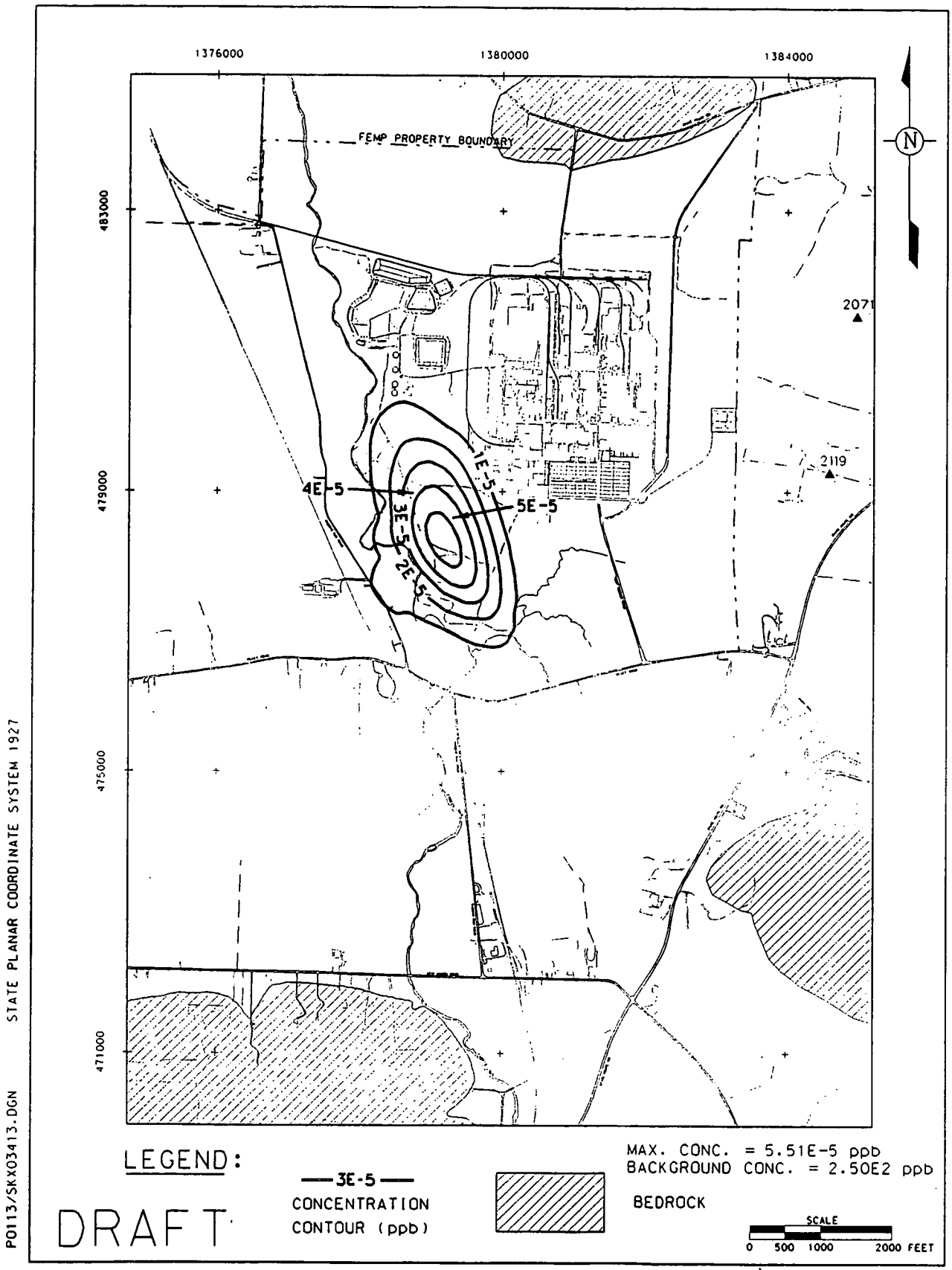

FIGURE H.I-8. Np-237 MAXIMUM CONCENTRATION CONTOURS. GMA. YEAR 10

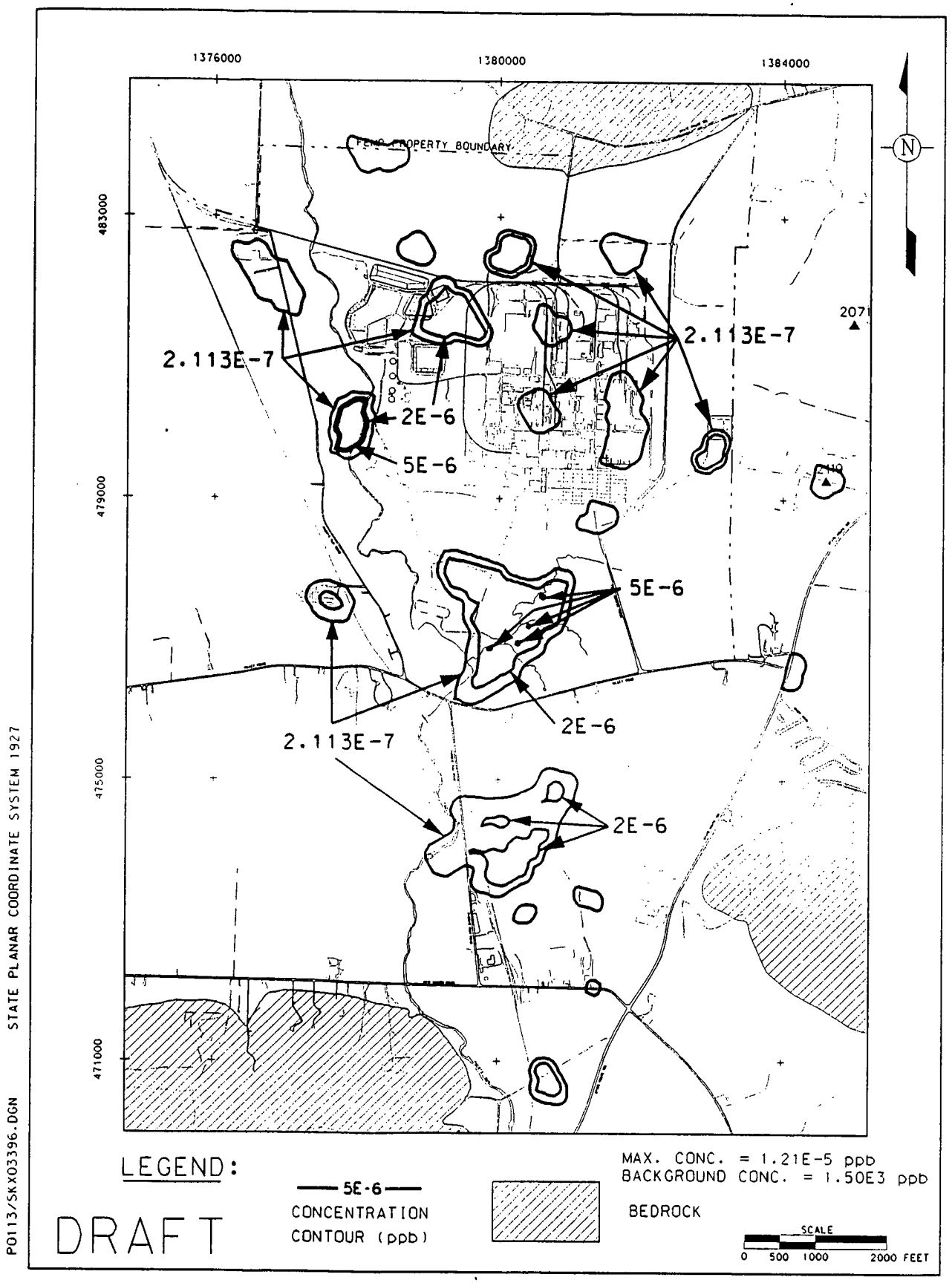

FIGURE H.I-9. Ra-226 MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 0

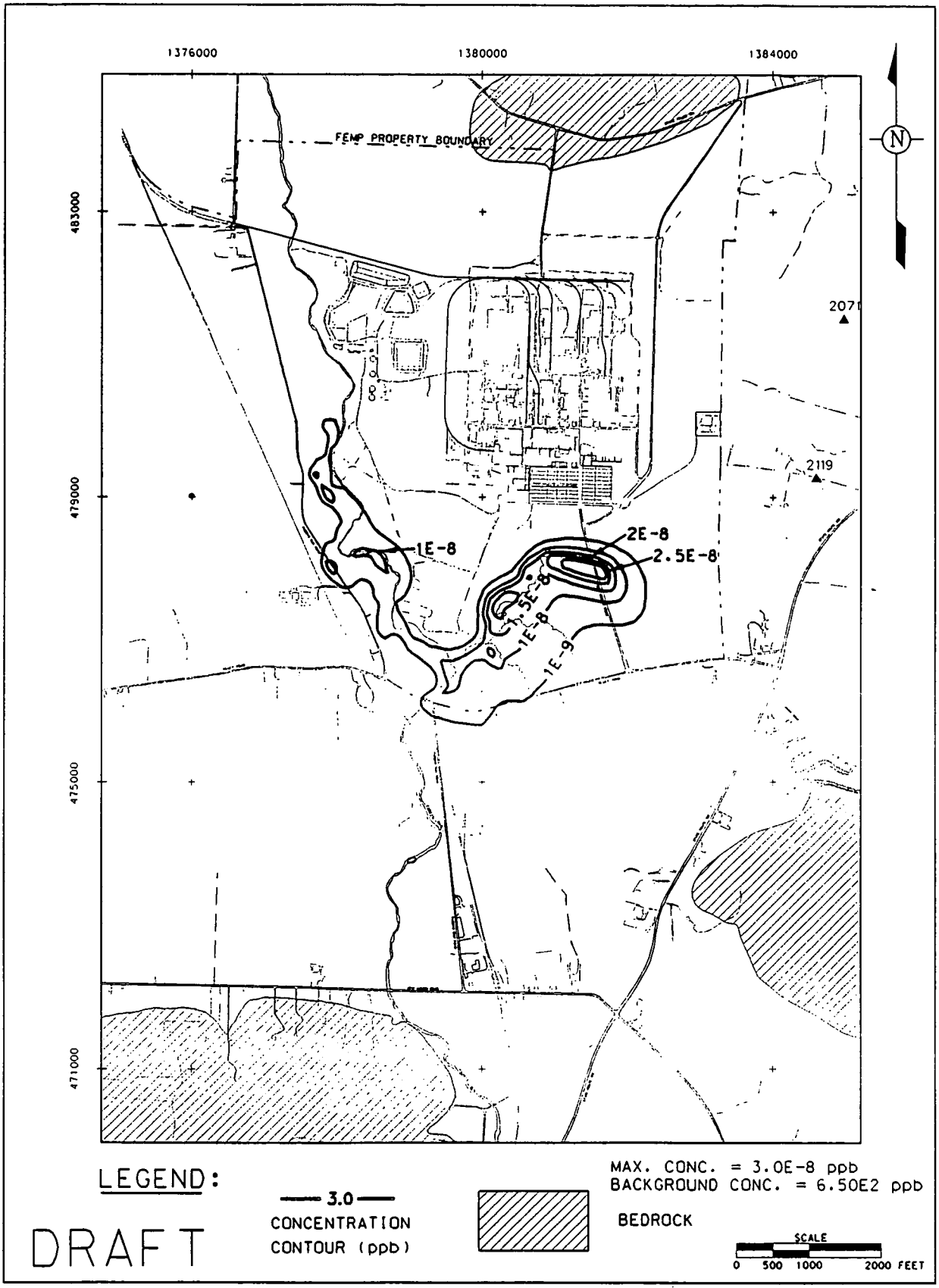

FIGURE H.I-10. Sr-90 MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 140

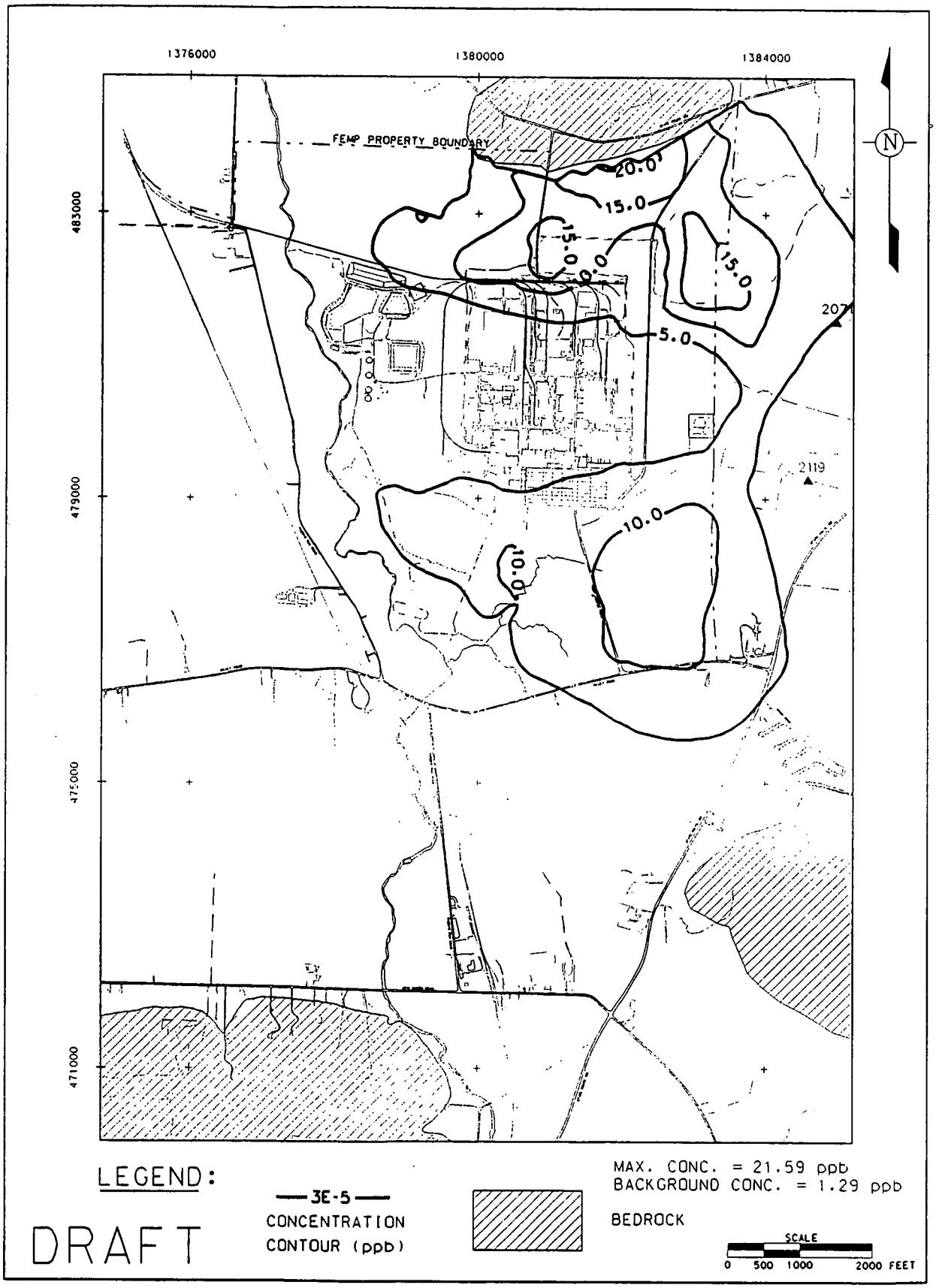

FIGURE H.1-11. URANIUM TOTAL MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 670

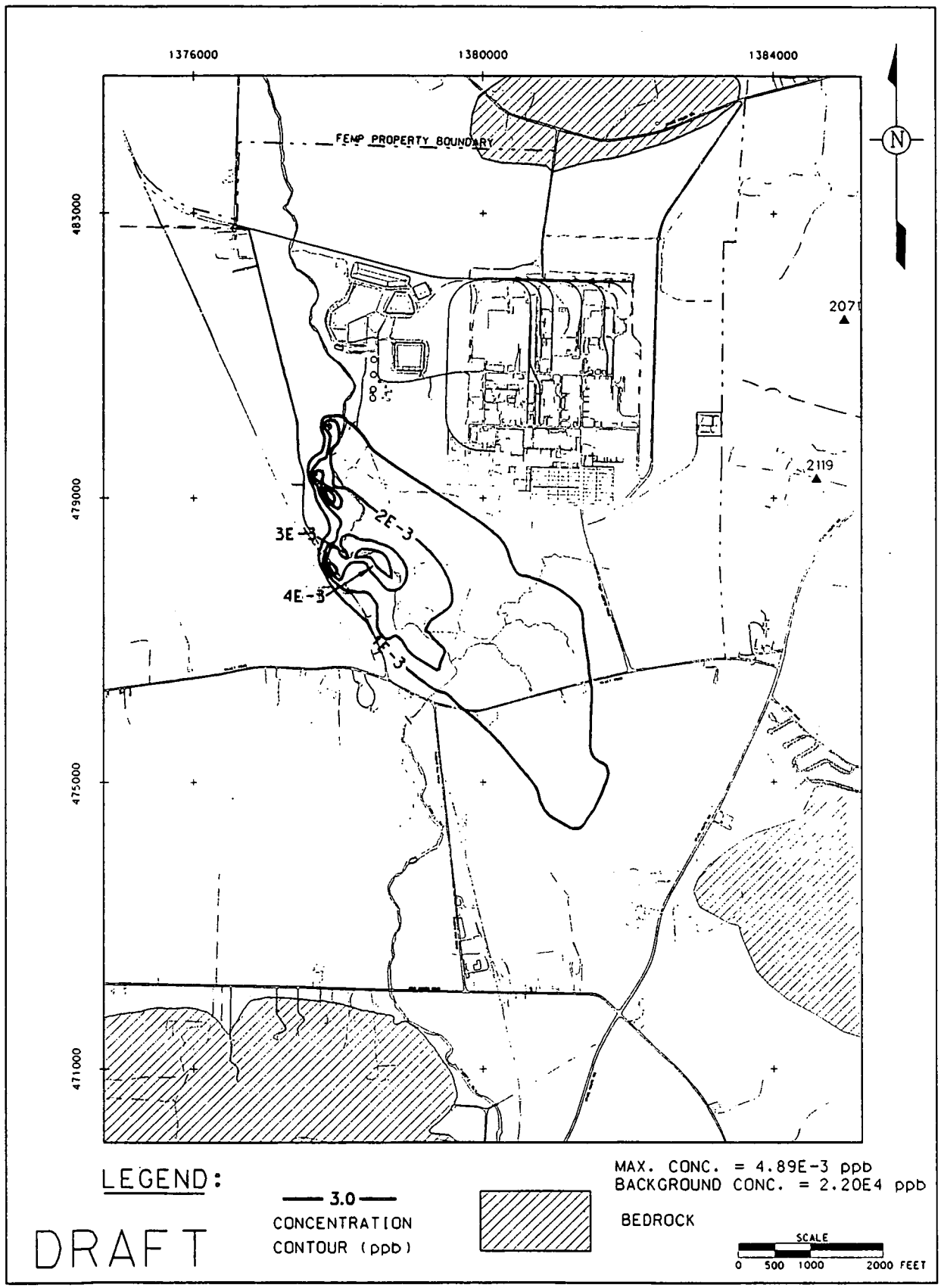

FIGURE H.I-12. Tc-99 MAXIMUM CONCENTRATION CONTOURS, GMA, YEAR 40

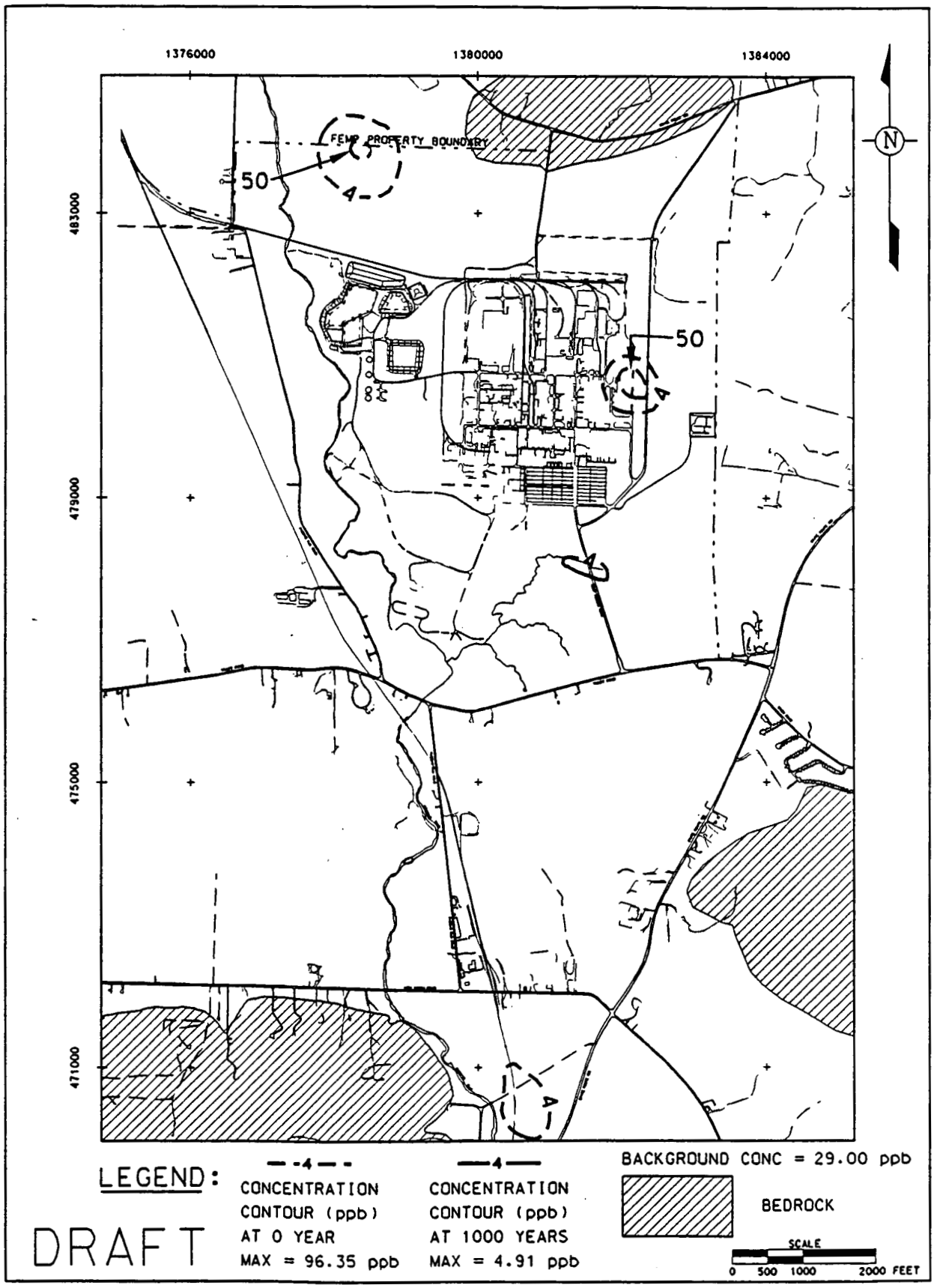

FIGURE H.1-13. ARSENIC CONCENTRATION CONTOURS, MOVEMENT OVER 1000 YEARS FOLLOWING REMEDIAL ACTIONS

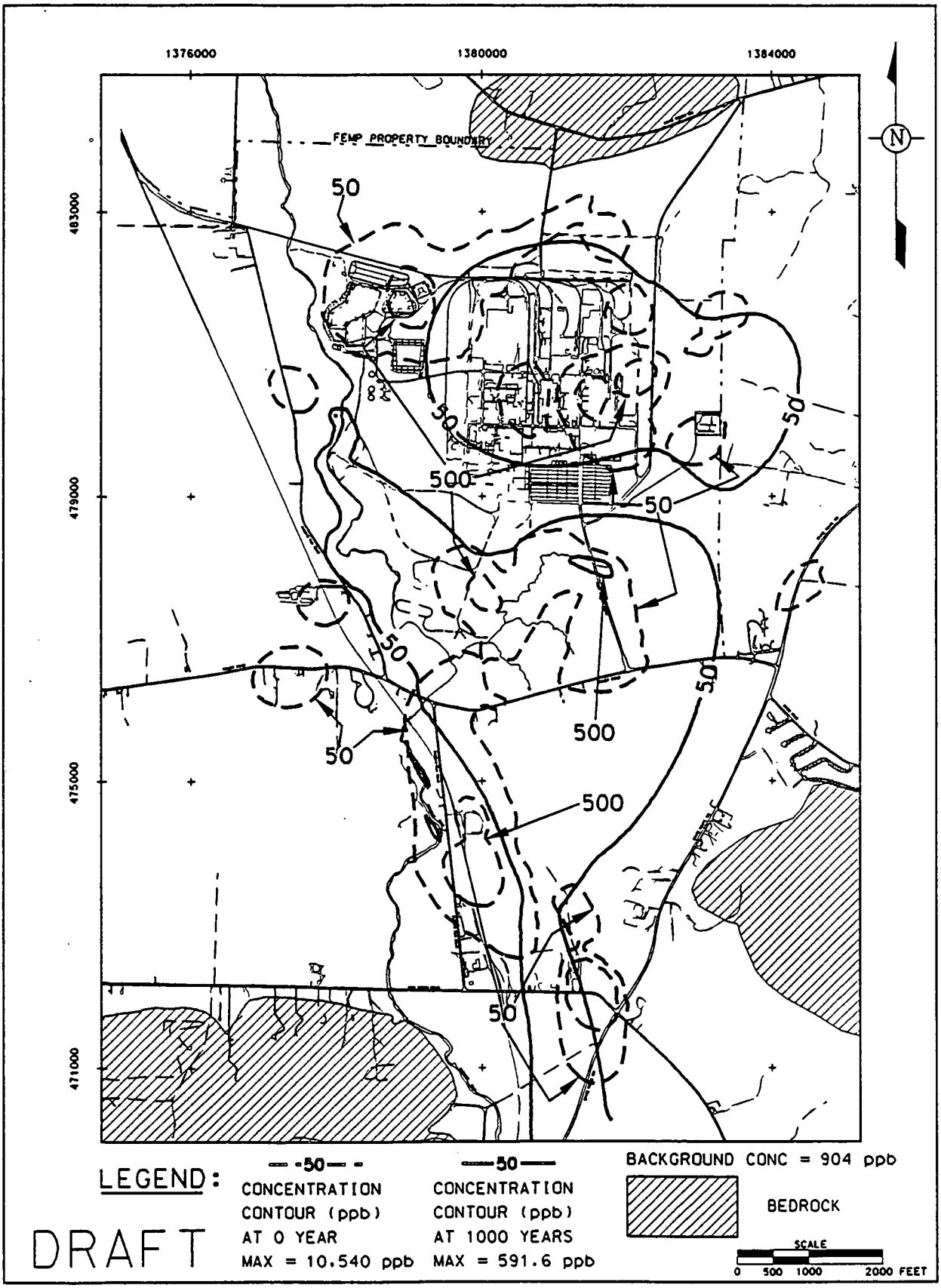

FIGURE H.I-14. MANGANESE CONCENTRATION CONTOURS, MOVEMENT OVER 1000 YEARS FOLLOWING REMEDIAL ACTIONS

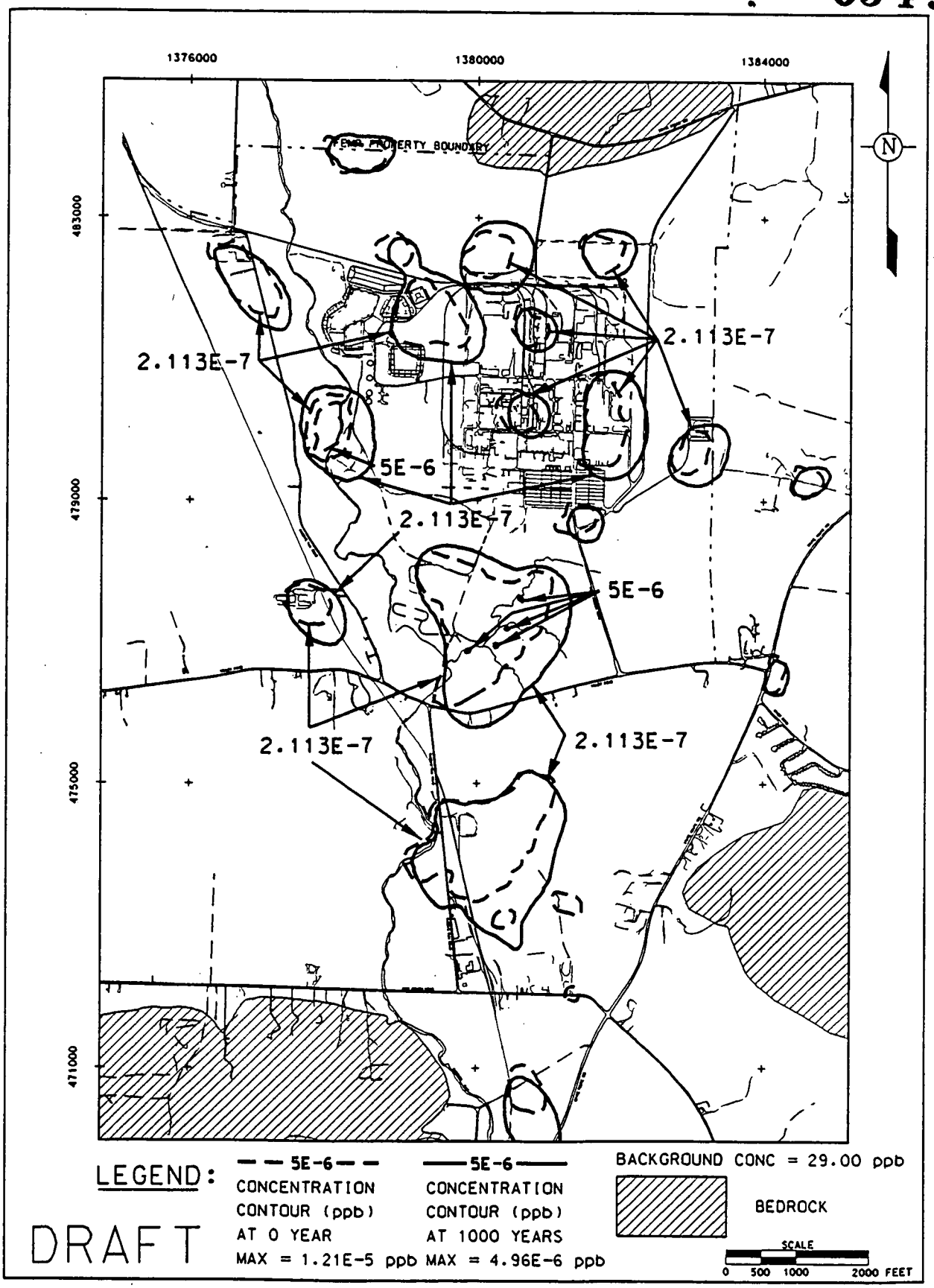

FIGURE H.I-15. Ra-226 CONCENTRATION CONTOURS. MOVEMENT OVER 1000 YEARS FOLLOWING REMEDIAL ACTIONS

ATTACHMENT H.I

WATER TRANSPORT MODELING

Neptunium-237

CRU 5 FS
Initial Mass and Concentration

Compound Type	Rad	
Kd Vadose 1	5.50E+01	ml/g
Kd Vadose 2	5.00E+00	ml/g
Rd Vadose 1	6.03E+02	
Rd Vadose 2	4.65E+01	
Screening Level	1.11E-06	mg/l
Lambda	8.87E-10	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	1.150E-03	1.671E+03	2.091E-05	5.50E+01
560B	2	0.000E+00	0.000E+00	0.000E+00	5.50E+01
560C	3	0.000E+00	0.000E+00	0.000E+00	5.50E+01
560D	4	0.000E+00	0.000E+00	0.000E+00	5.50E+01
570A-S	5	4.255E-04	6.184E+02	7.736E-06	5.50E+01
570B	6	0.000E+00	0.000E+00	0.000E+00	5.50E+01
570C	7	0.000E+00	0.000E+00	0.000E+00	5.50E+01
570D	8	0.000E+00	0.000E+00	0.000E+00	5.50E+01
570E	9	0.000E+00	0.000E+00	0.000E+00	5.50E+01
575A	10	0.000E+00	0.000E+00	0.000E+00	5.50E+01
575B	11	0.000E+00	0.000E+00	0.000E+00	5.50E+01
580A	12	0.000E+00	0.000E+00	0.000E+00	5.50E+01
581A	13	0.000E+00	0.000E+00	0.000E+00	5.50E+01
581B	14	0.000E+00	0.000E+00	0.000E+00	5.50E+01
581C	15	0.000E+00	0.000E+00	0.000E+00	5.50E+01
581D	16	0.000E+00	0.000E+00	0.000E+00	5.50E+01
582A	17	0.000E+00	0.000E+00	0.000E+00	5.50E+01
582B	18	0.000E+00	0.000E+00	0.000E+00	5.50E+01
PAA	19	0.000E+00	0.000E+00	0.000E+00	5.50E+01
PAB	20	0.000E+00	0.000E+00	0.000E+00	5.50E+01
PAC	21	0.000E+00	0.000E+00	0.000E+00	5.50E+01
PAD	22	0.000E+00	0.000E+00	0.000E+00	5.50E+01
PAE	23	0.000E+00	0.000E+00	0.000E+00	5.50E+01
PAF	24	0.000E+00	0.000E+00	0.000E+00	5.50E+01
PAG	25	0.000E+00	0.000E+00	0.000E+00	5.50E+01
PAH	26	0.000E+00	0.000E+00	0.000E+00	5.50E+01
PAI	27	0.000E+00	0.000E+00	0.000E+00	5.50E+01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	5.50E+01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	5.89E+06	2.64E-05

Radium-226

CRU 5 FS

Initial Mass and Concentration

Compound Type	Rad	
Kd Vadose 1	6.96E+02	ml/g
Kd Vadose 2	1.06E+02	ml/g
Rd Vadose 1	7.62E+03	
Rd Vadose 2	9.65E+02	
Screening Level	0.00E+00	mg/l
Lambda	1.19E-06	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	9.880E-07	1.436E+00	1.420E-09	6.96E+02
560B	2	1.600E-06	7.752E-01	2.299E-09	6.96E+02
560C	3	0.000E+00	0.000E+00	0.000E+00	6.96E+02
560D	4	0.000E+00	0.000E+00	0.000E+00	6.96E+02
570A-S	5	1.750E-06	2.544E+00	2.514E-09	6.96E+02
570B	6	0.000E+00	0.000E+00	0.000E+00	6.96E+02
570C	7	0.000E+00	0.000E+00	0.000E+00	6.96E+02
570D	8	0.000E+00	0.000E+00	0.000E+00	6.96E+02
570E	9	0.000E+00	0.000E+00	0.000E+00	6.96E+02
575A	10	7.080E-07	1.029E+00	1.017E-09	6.96E+02
575B	11	5.060E-07	7.354E-01	7.270E-10	6.96E+02
580A	12	3.030E-07	4.404E-01	4.353E-10	6.96E+02
581A	13	1.310E-06	6.347E-01	1.882E-09	6.96E+02
581B	14	0.000E+00	0.000E+00	0.000E+00	6.96E+02
581C	15	1.200E-06	5.814E-01	1.724E-09	6.96E+02
581D	16	0.000E+00	0.000E+00	0.000E+00	6.96E+02
582A	17	1.090E-06	1.584E+00	1.566E-09	6.96E+02
582B	18	0.000E+00	0.000E+00	0.000E+00	6.96E+02
PAA	19	0.000E+00	0.000E+00	0.000E+00	6.96E+02
PAB	20	0.000E+00	0.000E+00	0.000E+00	6.96E+02
PAC	21	0.000E+00	0.000E+00	0.000E+00	6.96E+02
PAD	22	0.000E+00	0.000E+00	0.000E+00	6.96E+02
PAE	23	0.000E+00	0.000E+00	0.000E+00	6.96E+02
PAF	24	0.000E+00	0.000E+00	0.000E+00	6.96E+02
PAG	25	0.000E+00	0.000E+00	0.000E+00	6.96E+02
PAH	26	0.000E+00	0.000E+00	0.000E+00	6.96E+02
PAI	27	2.630E-06	3.823E+00	3.779E-09	6.96E+02
WPAA	28	0.000E+00	0.000E+00	0.000E+00	6.96E+02

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	2.50E-11	1.12E-09

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	0.00E+00	0.00E+00

Strontium-90

CRU 5 FS

Initial Mass and Concentration

Compound Type	Rad	
Kd Vadose 1	1.00E+01	ml/g
Kd Vadose 2	2.50E+00	ml/g
Rd Vadose 1	1.11E+02	
Rd Vadose 2	2.37E+01	
Screening Level	2.26E-11	mg/l
Lambda	6.64E-05	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	1.022E-08	1.485E-02	1.022E-09	1.00E+01
560B	2	3.358E-08	1.627E-02	3.358E-09	1.00E+01
560C	3	0.000E+00	0.000E+00	0.000E+00	1.00E+01
560D	4	0.000E+00	0.000E+00	0.000E+00	1.00E+01
570A-S	5	6.569E-09	9.548E-03	6.569E-10	1.00E+01
570B	6	0.000E+00	0.000E+00	0.000E+00	1.00E+01
570C	7	0.000E+00	0.000E+00	0.000E+00	1.00E+01
570D	8	0.000E+00	0.000E+00	0.000E+00	1.00E+01
570E	9	0.000E+00	0.000E+00	0.000E+00	1.00E+01
575A	10	3.095E-09	4.498E-03	3.095E-10	1.00E+01
575B	11	3.095E-09	4.498E-03	3.095E-10	1.00E+01
580A	12	3.095E-09	4.498E-03	3.095E-10	1.00E+01
581A	13	1.117E-08	5.411E-03	1.117E-09	1.00E+01
581B	14	0.000E+00	0.000E+00	0.000E+00	1.00E+01
581C	15	3.139E-08	1.521E-02	3.139E-09	1.00E+01
581D	16	0.000E+00	0.000E+00	0.000E+00	1.00E+01
582A	17	8.759E-09	1.273E-02	8.759E-10	1.00E+01
582B	18	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAA	19	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAB	20	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAC	21	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAD	22	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAE	23	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAF	24	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAG	25	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAH	26	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAI	27	3.095E-09	4.498E-03	3.095E-10	1.00E+01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	1.00E+01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	3.37E-09	1.38E-09	2.46E-10	5.89E-09

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	1.12E+02	2.77E-09

Technetium-99

CRU 5 FS

Initial Mass and Concentration

Compound Type	Rad	
Kd Vadose 1	1.18E-01	ml/g
Kd Vadose 2	7.00E-02	ml/g
Rd Vadose 1	2.29E+00	
Rd Vadose 2	1.64E+00	
Screening Level	4.25E-06	mg/l
Lambda	8.92E-09	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	7.650E-05	1.112E+02	2.550E-06	1.18E-01
560B	2	9.410E-05	4.559E+01	3.137E-06	1.18E-01
560C	3	0.000E+00	0.000E+00	0.000E+00	1.18E-01
560D	4	0.000E+00	0.000E+00	0.000E+00	1.18E-01
570A-S	5	0.000E+00	0.000E+00	0.000E+00	1.18E-01
570B	6	0.000E+00	0.000E+00	0.000E+00	1.18E-01
570C	7	0.000E+00	0.000E+00	0.000E+00	1.18E-01
570D	8	0.000E+00	0.000E+00	0.000E+00	1.18E-01
570E	9	0.000E+00	0.000E+00	0.000E+00	1.18E-01
575A	10	0.000E+00	0.000E+00	0.000E+00	1.18E-01
575B	11	0.000E+00	0.000E+00	0.000E+00	1.18E-01
580A	12	0.000E+00	0.000E+00	0.000E+00	1.18E-01
581A	13	6.470E-05	3.135E+01	2.157E-06	1.18E-01
581B	14	0.000E+00	0.000E+00	0.000E+00	1.18E-01
581C	15	0.000E+00	0.000E+00	0.000E+00	1.18E-01
581D	16	0.000E+00	0.000E+00	0.000E+00	1.18E-01
582A	17	0.000E+00	0.000E+00	0.000E+00	1.18E-01
582B	18	0.000E+00	0.000E+00	0.000E+00	1.18E-01
PAA	19	0.000E+00	0.000E+00	0.000E+00	1.18E-01
PAB	20	0.000E+00	0.000E+00	0.000E+00	1.18E-01
PAC	21	0.000E+00	0.000E+00	0.000E+00	1.18E-01
PAD	22	0.000E+00	0.000E+00	0.000E+00	1.18E-01
PAE	23	0.000E+00	0.000E+00	0.000E+00	1.18E-01
PAF	24	0.000E+00	0.000E+00	0.000E+00	1.18E-01
PAG	25	0.000E+00	0.000E+00	0.000E+00	1.18E-01
PAH	26	0.000E+00	0.000E+00	0.000E+00	1.18E-01
PAI	27	0.000E+00	0.000E+00	0.000E+00	1.18E-01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	1.18E-01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	1.14E-03	4.16E-04	3.33E-05	0.00E+00

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	4.06E+05	3.33E-06

Uranium – Total

CRU 5 FS
Initial Mass and Concentration
Sensitivity Analysis – 5

Compound Type	Rad	
Kd Vadose 1	1.50E+01	ml/g
Kd Vadose 2	1.78E+00	ml/g
Rd Vadose 1	1.65E+02	
Rd Vadose 2	1.72E+01	
Screening Level	2.57E–02	mg/l
Lambda	4.25E–13	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 for Concentration (ml/g)
560A	1	2.000E+01	2.907E+07	6.154E–02	3.25E+02
560B	2	2.000E+01	9.690E+06	6.154E–02	3.25E+02
560C	3	0.000E+00	0.000E+00	0.000E+00	1.50E+01
560D	4	0.000E+00	0.000E+00	0.000E+00	3.25E+02
570A–S	5	2.283E+01	3.318E+07	7.024E–02	3.25E+02
570B	6	0.000E+00	0.000E+00	0.000E+00	3.25E+02
570C	7	0.000E+00	0.000E+00	0.000E+00	3.25E+02
570D	8	0.000E+00	0.000E+00	0.000E+00	3.25E+02
570E	9	0.000E+00	0.000E+00	0.000E+00	3.25E+02
575A	10	1.908E+01	2.773E+07	5.870E–02	3.25E+02
575B	11	4.673E+01	6.791E+07	1.438E–01	3.25E+02
580A	12	2.143E+00	3.115E+06	6.593E–03	3.25E+02
581A	13	2.130E+01	1.032E+07	6.554E–02	3.25E+02
581B	14	0.000E+00	0.000E+00	0.000E+00	3.25E+02
581C	15	4.760E+01	2.306E+07	1.465E–01	3.25E+02
581D	16	0.000E+00	0.000E+00	0.000E+00	1.50E+01
582A	17	1.256E+01	1.825E+07	3.864E–02	3.25E+02
582B	18	0.000E+00	0.000E+00	0.000E+00	3.25E+02
PAA	19	0.000E+00	0.000E+00	0.000E+00	1.50E+01
PAB	20	0.000E+00	0.000E+00	0.000E+00	1.50E+01
PAC	21	0.000E+00	0.000E+00	0.000E+00	1.50E+01
PAD	22	0.000E+00	0.000E+00	0.000E+00	1.50E+01
PAE	23	0.000E+00	0.000E+00	0.000E+00	1.50E+01
PAF	24	0.000E+00	0.000E+00	0.000E+00	3.25E+02
PAG	25	0.000E+00	0.000E+00	0.000E+00	3.25E+02
PAH	26	0.000E+00	0.000E+00	0.000E+00	3.25E+02
PAI	27	1.345E+01	1.955E+07	4.139E–02	3.25E+02
WPAA	28	0.000E+00	0.000E+00	0.000E+00	3.25E+02

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	2.77E–01	2.02E–01	2.45E–02	3.73E–01

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	1.34E+08	1.98E–03
Active Flyash Pile	4.73E+06	1.98E–02
Lime Sludge Ponds	1.95E+07	2.08E–03
South Field and Inactive Flyash Pile	1.55E+08	4.17E–06
Perched Water	2.85E+06	1.19E–01
Disposal Cell	4.06E+11	6.67E+00

Antimony

CRU 5 FS

Initial Mass and Concentration

Compound Type	Inorg	
Kd Vadose 1	2.50E+02	ml/g
Kd Vadose 2	4.50E+01	ml/g
Rd Vadose 1	2.74E+03	
Rd Vadose 2	4.10E+02	
Screening Level	1.50E-03	mg/l
Lambda	1.00E-50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	3.200E+00	4.651E+06	1.280E-02	2.50E+02
560B	2	2.640E+01	1.279E+07	1.056E-01	2.50E+02
560C	3	0.000E+00	0.000E+00	0.000E+00	2.50E+02
560D	4	0.000E+00	0.000E+00	0.000E+00	2.50E+02
570A-S	5	7.600E-01	1.105E+06	3.040E-03	2.50E+02
570B	6	0.000E+00	0.000E+00	0.000E+00	2.50E+02
570C	7	0.000E+00	0.000E+00	0.000E+00	2.50E+02
570D	8	0.000E+00	0.000E+00	0.000E+00	2.50E+02
570E	9	0.000E+00	0.000E+00	0.000E+00	2.50E+02
575A	10	7.600E-01	1.105E+06	3.040E-03	2.50E+02
575B	11	7.600E-01	1.105E+06	3.040E-03	2.50E+02
580A	12	7.600E-01	1.105E+06	3.040E-03	2.50E+02
581A	13	4.100E+00	1.986E+06	1.640E-02	2.50E+02
581B	14	0.000E+00	0.000E+00	0.000E+00	2.50E+02
581C	15	7.600E-01	3.682E+05	3.040E-03	2.50E+02
581D	16	0.000E+00	0.000E+00	0.000E+00	2.50E+02
582A	17	7.600E-01	1.105E+06	3.040E-03	2.50E+02
582B	18	0.000E+00	0.000E+00	0.000E+00	2.50E+02
PAA	19	0.000E+00	0.000E+00	0.000E+00	2.50E+02
PAB	20	0.000E+00	0.000E+00	0.000E+00	2.50E+02
PAC	21	0.000E+00	0.000E+00	0.000E+00	2.50E+02
PAD	22	0.000E+00	0.000E+00	0.000E+00	2.50E+02
PAE	23	0.000E+00	0.000E+00	0.000E+00	2.50E+02
PAF	24	0.000E+00	0.000E+00	0.000E+00	2.50E+02
PAG	25	0.000E+00	0.000E+00	0.000E+00	2.50E+02
PAH	26	0.000E+00	0.000E+00	0.000E+00	2.50E+02
PAI	27	7.600E-01	1.105E+06	3.040E-03	2.50E+02
WPAA	28	0.000E+00	0.000E+00	0.000E+00	2.50E+02

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	6.31E-02	2.92E-02	3.95E-03	6.41E-02

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	0.00E+00	0.00E+00

Arsenic

CRU 5 FS
Initial Mass and Concentration

Compound Type	Inorg	
Kd Vadose 1	2.00E+02	ml/g
Kd Vadose 2	2.00E+02	ml/g
Rd Vadose 1	2.19E+03	
Rd Vadose 2	1.82E+03	
Screening Level	4.90E−06	mg/l
Lambda	1.00E−50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	1.210E+01	1.759E+07	6.050E−02	2.00E+02
560B	2	8.820E+00	4.273E+06	4.410E−02	2.00E+02
560C	3	0.000E+00	0.000E+00	0.000E+00	2.00E+02
560D	4	0.000E+00	0.000E+00	0.000E+00	2.00E+02
570A−S	5	2.600E+01	3.779E+07	1.300E−01	2.00E+02
570B	6	0.000E+00	0.000E+00	0.000E+00	2.00E+02
570C	7	0.000E+00	0.000E+00	0.000E+00	2.00E+02
570D	8	0.000E+00	0.000E+00	0.000E+00	2.00E+02
570E	9	0.000E+00	0.000E+00	0.000E+00	2.00E+02
575A	10	7.300E+00	1.061E+07	3.650E−02	2.00E+02
575B	11	3.700E+00	5.378E+06	1.850E−02	2.00E+02
580A	12	6.500E+00	9.447E+06	3.250E−02	2.00E+02
581A	13	9.840E+00	4.767E+06	4.920E−02	2.00E+02
581B	14	0.000E+00	0.000E+00	0.000E+00	2.00E+02
581C	15	3.300E+00	1.599E+06	1.650E−02	2.00E+02
581D	16	0.000E+00	0.000E+00	0.000E+00	2.00E+02
582A	17	8.590E+00	1.249E+07	4.295E−02	2.00E+02
582B	18	0.000E+00	0.000E+00	0.000E+00	2.00E+02
PAA	19	0.000E+00	0.000E+00	0.000E+00	2.00E+02
PAB	20	0.000E+00	0.000E+00	0.000E+00	2.00E+02
PAC	21	0.000E+00	0.000E+00	0.000E+00	2.00E+02
PAD	22	0.000E+00	0.000E+00	0.000E+00	2.00E+02
PAE	23	0.000E+00	0.000E+00	0.000E+00	2.00E+02
PAF	24	0.000E+00	0.000E+00	0.000E+00	2.00E+02
PAG	25	0.000E+00	0.000E+00	0.000E+00	2.00E+02
PAH	26	0.000E+00	0.000E+00	0.000E+00	2.00E+02
PAI	27	6.400E+00	9.302E+06	3.200E−02	2.00E+02
WPAA	28	0.000E+00	0.000E+00	0.000E+00	2.00E+02

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	3.50E−01	1.95E−01	3.35E−02	7.27E−01

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	0.00E+00	0.00E+00

Boron

CRU 5 FS
Initial Mass and Concentration

Compound Type	Inorg	
Kd Vadose 1	3.00E+00	ml/g
Kd Vadose 2	3.00E+00	ml/g
Rd Vadose 1	3.39E+01	
Rd Vadose 2	2.83E+01	
Screening Level	3.26E−01	mg/l
Lambda	1.00E−50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	1.430E+01	2.078E+07	4.767E+00	3.00E+00
560B	2	1.370E+01	6.637E+06	4.567E+00	3.00E+00
560C	3	0.000E+00	0.000E+00	0.000E+00	3.00E+00
560D	4	0.000E+00	0.000E+00	0.000E+00	3.00E+00
570A-S	5	1.370E+01	1.991E+07	4.567E+00	3.00E+00
570B	6	0.000E+00	0.000E+00	0.000E+00	3.00E+00
570C	7	0.000E+00	0.000E+00	0.000E+00	3.00E+00
570D	8	0.000E+00	0.000E+00	0.000E+00	3.00E+00
570E	9	0.000E+00	0.000E+00	0.000E+00	3.00E+00
575A	10	1.370E+01	1.991E+07	4.567E+00	3.00E+00
575B	11	1.370E+01	1.991E+07	4.567E+00	3.00E+00
580A	12	1.370E+01	1.991E+07	4.567E+00	3.00E+00
581A	13	1.430E+01	6.928E+06	4.767E+00	3.00E+00
581B	14	0.000E+00	0.000E+00	0.000E+00	3.00E+00
581C	15	1.370E+01	6.637E+06	4.567E+00	3.00E+00
581D	16	0.000E+00	0.000E+00	0.000E+00	3.00E+00
582A	17	1.430E+01	2.078E+07	4.767E+00	3.00E+00
582B	18	0.000E+00	0.000E+00	0.000E+00	3.00E+00
PAA	19	0.000E+00	0.000E+00	0.000E+00	3.00E+00
PAB	20	0.000E+00	0.000E+00	0.000E+00	3.00E+00
PAC	21	0.000E+00	0.000E+00	0.000E+00	3.00E+00
PAD	22	0.000E+00	0.000E+00	0.000E+00	3.00E+00
PAE	23	0.000E+00	0.000E+00	0.000E+00	3.00E+00
PAF	24	0.000E+00	0.000E+00	0.000E+00	3.00E+00
PAG	25	0.000E+00	0.000E+00	0.000E+00	3.00E+00
PAH	26	0.000E+00	0.000E+00	0.000E+00	3.00E+00
PAI	27	1.370E+01	1.991E+07	4.567E+00	3.00E+00
WPAA	28	0.000E+00	0.000E+00	0.000E+00	3.00E+00

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	5.56E+10	4.57E+00

Chromium (Hex)

CRU 5 FS

Initial Mass and Concentration

Compound Type	Inorg	
Kd Vadose 1	3.70E+01	ml/g
Kd Vadose 2	3.70E+00	ml/g
Rd Vadose 1	4.06E+02	
Rd Vadose 2	3.46E+01	
Screening Level	2.22E−02	mg/l
Lambda	1.00E−50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	1.460E+00	2.122E+06	3.946E−02	3.70E+01
560B	2	3.430E+00	1.662E+06	9.270E−02	3.70E+01
560C	3	0.000E+00	0.000E+00	0.000E+00	3.70E+01
560D	4	0.000E+00	0.000E+00	0.000E+00	3.70E+01
570A−S	5	1.670E+00	2.427E+06	4.514E−02	3.70E+01
570B	6	0.000E+00	0.000E+00	0.000E+00	3.70E+01
570C	7	0.000E+00	0.000E+00	0.000E+00	3.70E+01
570D	8	0.000E+00	0.000E+00	0.000E+00	3.70E+01
570E	9	0.000E+00	0.000E+00	0.000E+00	3.70E+01
575A	10	1.400E+00	2.035E+06	3.784E−02	3.70E+01
575B	11	1.130E+00	1.642E+06	3.054E−02	3.70E+01
580A	12	1.130E+00	1.642E+06	3.054E−02	3.70E+01
581A	13	1.460E+00	7.073E+05	3.946E−02	3.70E+01
581B	14	0.000E+00	0.000E+00	0.000E+00	3.70E+01
581C	15	9.800E−01	4.748E+05	2.649E−02	3.70E+01
581D	16	0.000E+00	0.000E+00	0.000E+00	3.70E+01
582A	17	1.380E+00	2.006E+06	3.730E−02	3.70E+01
582B	18	0.000E+00	0.000E+00	0.000E+00	3.70E+01
PAA	19	0.000E+00	0.000E+00	0.000E+00	3.70E+01
PAB	20	0.000E+00	0.000E+00	0.000E+00	3.70E+01
PAC	21	0.000E+00	0.000E+00	0.000E+00	3.70E+01
PAD	22	0.000E+00	0.000E+00	0.000E+00	3.70E+01
PAE	23	0.000E+00	0.000E+00	0.000E+00	3.70E+01
PAF	24	0.000E+00	0.000E+00	0.000E+00	3.70E+01
PAG	25	0.000E+00	0.000E+00	0.000E+00	3.70E+01
PAH	26	0.000E+00	0.000E+00	0.000E+00	3.70E+01
PAI	27	1.970E+00	2.863E+06	5.324E−02	3.70E+01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	3.70E+01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	1.27E+10	8.43E−02

Magnesium
CRU 5 FS
Initial Mass and Concentration

Compound Type	Inorg	
Kd Vadose 1	4.50E+00	ml/g
Kd Vadose 2	4.50E+00	ml/g
Rd Vadose 1	5.03E+01	
Rd Vadose 2	4.19E+01	
Screening Level	3.52E+01	mg/l
Lambda	1.00E−50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	2.810E+04	4.084E+10	6.244E+03	4.50E+00
560B	2	4.860E+04	2.355E+10	1.080E+04	4.50E+00
560C	3	0.000E+00	0.000E+00	0.000E+00	4.50E+00
560D	4	0.000E+00	0.000E+00	0.000E+00	4.50E+00
570A−S	5	2.319E+04	3.371E+10	5.154E+03	4.50E+00
570B	6	0.000E+00	0.000E+00	0.000E+00	4.50E+00
570C	7	0.000E+00	0.000E+00	0.000E+00	4.50E+00
570D	8	0.000E+00	0.000E+00	0.000E+00	4.50E+00
570E	9	0.000E+00	0.000E+00	0.000E+00	4.50E+00
575A	10	2.980E+04	4.331E+10	6.622E+03	4.50E+00
575B	11	2.050E+03	2.980E+09	4.556E+02	4.50E+00
580A	12	8.850E+03	1.286E+10	1.967E+03	4.50E+00
581A	13	3.540E+04	1.715E+10	7.867E+03	4.50E+00
581B	14	0.000E+00	0.000E+00	0.000E+00	4.50E+00
581C	15	1.200E+03	5.814E+08	2.667E+02	4.50E+00
581D	16	0.000E+00	0.000E+00	0.000E+00	4.50E+00
582A	17	1.910E+03	2.776E+09	4.244E+02	4.50E+00
582B	18	0.000E+00	0.000E+00	0.000E+00	4.50E+00
PAA	19	0.000E+00	0.000E+00	0.000E+00	4.50E+00
PAB	20	0.000E+00	0.000E+00	0.000E+00	4.50E+00
PAC	21	0.000E+00	0.000E+00	0.000E+00	4.50E+00
PAD	22	0.000E+00	0.000E+00	0.000E+00	4.50E+00
PAE	23	0.000E+00	0.000E+00	0.000E+00	4.50E+00
PAF	24	0.000E+00	0.000E+00	0.000E+00	4.50E+00
PAG	25	0.000E+00	0.000E+00	0.000E+00	4.50E+00
PAH	26	0.000E+00	0.000E+00	0.000E+00	4.50E+00
PAI	27	2.280E+04	3.314E+10	5.067E+03	4.50E+00
WPAA	28	0.000E+00	0.000E+00	0.000E+00	4.50E+00

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	2.78E+04	1.94E+04	1.84E+03	1.21E+04

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	1.07E+14	5.87E+03

Manganese

CRU 5 FS
Initial Mass and Concentration

Compound Type	Inorg	
Kd Vadose 1	1.80E+02	ml/g
Kd Vadose 2	5.00E+01	ml/g
Rd Vadose 1	1.97E+03	
Rd Vadose 2	4.56E+02	
Screening Level	1.80E−02	mg/l
Lambda	1.00E−50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	8.630E+02	1.254E+09	4.794E+00	1.80E+02
560B	2	8.300E+02	4.021E+08	4.611E+00	1.80E+02
560C	3	0.000E+00	0.000E+00	0.000E+00	1.80E+02
560D	4	0.000E+00	0.000E+00	0.000E+00	1.80E+02
570A−S	5	7.940E+02	1.154E+09	4.411E+00	1.80E+02
570B	6	0.000E+00	0.000E+00	0.000E+00	1.80E+02
570C	7	0.000E+00	0.000E+00	0.000E+00	1.80E+02
570D	8	0.000E+00	0.000E+00	0.000E+00	1.80E+02
570E	9	0.000E+00	0.000E+00	0.000E+00	1.80E+02
575A	10	1.350E+03	1.962E+09	7.500E+00	1.80E+02
575B	11	1.170E+03	1.701E+09	6.500E+00	1.80E+02
580A	12	4.430E+02	6.439E+08	2.461E+00	1.80E+02
581A	13	3.420E+03	1.657E+09	1.900E+01	1.80E+02
581B	14	0.000E+00	0.000E+00	0.000E+00	1.80E+02
581C	15	9.020E+02	4.370E+08	5.011E+00	1.80E+02
581D	16	0.000E+00	0.000E+00	0.000E+00	1.80E+02
582A	17	6.190E+02	8.997E+08	3.439E+00	1.80E+02
582B	18	0.000E+00	0.000E+00	0.000E+00	1.80E+02
PAA	19	0.000E+00	0.000E+00	0.000E+00	1.80E+02
PAB	20	0.000E+00	0.000E+00	0.000E+00	1.80E+02
PAC	21	0.000E+00	0.000E+00	0.000E+00	1.80E+02
PAD	22	0.000E+00	0.000E+00	0.000E+00	1.80E+02
PAE	23	0.000E+00	0.000E+00	0.000E+00	1.80E+02
PAF	24	0.000E+00	0.000E+00	0.000E+00	1.80E+02
PAG	25	0.000E+00	0.000E+00	0.000E+00	1.80E+02
PAH	26	0.000E+00	0.000E+00	0.000E+00	1.80E+02
PAI	27	1.720E+03	2.500E+09	9.556E+00	1.80E+02
WPAA	28	0.000E+00	0.000E+00	0.000E+00	1.80E+02

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	3.55E+01	2.64E+01	4.27E+00	8.73E+01

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	0.00E+00	0.00E+00

Mercury
CRU 5 FS
Initial Mass and Concentration

Compound Type	Inorg	
Kd Vadose 1	1.00E+01	ml/g
Kd Vadose 2	1.00E+01	ml/g
Rd Vadose 1	1.11E+02	
Rd Vadose 2	9.19E+01	
Screening Level	1.58E−04	mg/l
Lambda	1.00E−50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	3.000E−01	4.360E+05	3.000E−02	1.00E+01
560B	2	3.000E−01	1.453E+05	3.000E−02	1.00E+01
560C	3	0.000E+00	0.000E+00	0.000E+00	1.00E+01
560D	4	0.000E+00	0.000E+00	0.000E+00	1.00E+01
570A−S	5	3.000E−01	4.360E+05	3.000E−02	1.00E+01
570B	6	0.000E+00	0.000E+00	0.000E+00	1.00E+01
570C	7	0.000E+00	0.000E+00	0.000E+00	1.00E+01
570D	8	0.000E+00	0.000E+00	0.000E+00	1.00E+01
570E	9	0.000E+00	0.000E+00	0.000E+00	1.00E+01
575A	10	3.000E−01	4.360E+05	3.000E−02	1.00E+01
575B	11	3.000E−01	4.360E+05	3.000E−02	1.00E+01
580A	12	3.000E−01	4.360E+05	3.000E−02	1.00E+01
581A	13	5.700E−01	2.762E+05	5.700E−02	1.00E+01
581B	14	0.000E+00	0.000E+00	0.000E+00	1.00E+01
581C	15	3.000E−01	1.453E+05	3.000E−02	1.00E+01
581D	16	0.000E+00	0.000E+00	0.000E+00	1.00E+01
582A	17	3.000E−01	4.360E+05	3.000E−02	1.00E+01
582B	18	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAA	19	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAB	20	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAC	21	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAD	22	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAE	23	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAF	24	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAG	25	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAH	26	0.000E+00	0.000E+00	0.000E+00	1.00E+01
PAI	27	3.000E−01	4.360E+05	3.000E−02	1.00E+01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	1.00E+01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	2.31E−01	1.44E−01	2.73E−02	6.23E−01

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	2.21E+09	5.44E−02

000189

Alpha–chlordane

CRU 5 FS
Initial Mass and Concentration

Compound Type	Org–P	
Kd Vadose 1	3.34E+00	ml/g
Kd Vadose 2	6.31E–01	ml/g
Rd Vadose 1	3.76E+01	
Rd Vadose 2	6.73E+00	
Screening Level	4.51E–05	mg/l
Lambda	1.00E–51	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	0.000E+00	0.000E+00	0.000E+00	3.42E+00
560B	2	0.000E+00	0.000E+00	0.000E+00	3.37E+00
560C	3	0.000E+00	0.000E+00	0.000E+00	3.42E+00
560D	4	0.000E+00	0.000E+00	0.000E+00	3.34E+00
570A–S	5	0.000E+00	0.000E+00	0.000E+00	3.43E+00
570B	6	0.000E+00	0.000E+00	0.000E+00	3.49E+00
570C	7	0.000E+00	0.000E+00	0.000E+00	3.34E+00
570D	8	0.000E+00	0.000E+00	0.000E+00	3.34E+00
570E	9	0.000E+00	0.000E+00	0.000E+00	3.49E+00
575A	10	0.000E+00	0.000E+00	0.000E+00	3.42E+00
575B	11	0.000E+00	0.000E+00	0.000E+00	3.49E+00
580A	12	0.000E+00	0.000E+00	0.000E+00	3.42E+00
581A	13	0.000E+00	0.000E+00	0.000E+00	3.34E+00
581B	14	0.000E+00	0.000E+00	0.000E+00	3.34E+00
581C	15	0.000E+00	0.000E+00	0.000E+00	3.25E+00
581D	16	0.000E+00	0.000E+00	0.000E+00	3.34E+00
582A	17	0.000E+00	0.000E+00	0.000E+00	3.25E+00
582B	18	0.000E+00	0.000E+00	0.000E+00	3.34E+00
PAA	19	0.000E+00	0.000E+00	0.000E+00	3.34E+00
PAB	20	0.000E+00	0.000E+00	0.000E+00	3.34E+00
PAC	21	0.000E+00	0.000E+00	0.000E+00	3.34E+00
PAD	22	0.000E+00	0.000E+00	0.000E+00	3.34E+00
PAE	23	0.000E+00	0.000E+00	0.000E+00	3.34E+00
PAF	24	0.000E+00	0.000E+00	0.000E+00	3.34E+00
PAG	25	0.000E+00	0.000E+00	0.000E+00	3.34E+00
PAH	26	0.000E+00	0.000E+00	0.000E+00	3.34E+00
PAI	27	2.800E–03	4.070E+03	8.376E–04	3.34E+00
WPAA	28	0.000E+00	0.000E+00	0.000E+00	3.34E+00

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	9.98E–06	4.46E–04

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	5.52E+05	4.18E–05

Bis(2-chloroisopropyl)ethe

CRU 5 FS

Initial Mass and Concentration

Compound Type	Org	
Kd Vadose 1	6.99E-01	ml/g
Kd Vadose 2	1.32E-01	ml/g
Rd Vadose 1	8.65E+00	
Rd Vadose 2	2.20E+00	
Screening Level	1.63E-03	mg/l
Lambda	1.00E-50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	0.000E+00	0.000E+00	0.000E+00	7.14E-01
560B	2	0.000E+00	0.000E+00	0.000E+00	7.05E-01
560C	3	0.000E+00	0.000E+00	0.000E+00	7.14E-01
560D	4	0.000E+00	0.000E+00	0.000E+00	6.99E-01
570A-S	5	4.400E-02	6.395E+04	6.299E-02	7.18E-01
570B	6	0.000E+00	0.000E+00	0.000E+00	7.30E-01
570C	7	0.000E+00	0.000E+00	0.000E+00	6.99E-01
570D	8	0.000E+00	0.000E+00	0.000E+00	6.99E-01
570E	9	0.000E+00	0.000E+00	0.000E+00	7.30E-01
575A	10	0.000E+00	0.000E+00	0.000E+00	7.14E-01
575B	11	0.000E+00	0.000E+00	0.000E+00	7.30E-01
580A	12	0.000E+00	0.000E+00	0.000E+00	7.14E-01
581A	13	0.000E+00	0.000E+00	0.000E+00	6.99E-01
581B	14	0.000E+00	0.000E+00	0.000E+00	6.99E-01
581C	15	0.000E+00	0.000E+00	0.000E+00	6.79E-01
581D	16	0.000E+00	0.000E+00	0.000E+00	6.99E-01
582A	17	0.000E+00	0.000E+00	0.000E+00	6.79E-01
582B	18	0.000E+00	0.000E+00	0.000E+00	6.99E-01
PAA	19	0.000E+00	0.000E+00	0.000E+00	6.99E-01
PAB	20	0.000E+00	0.000E+00	0.000E+00	6.99E-01
PAC	21	0.000E+00	0.000E+00	0.000E+00	6.99E-01
PAD	22	0.000E+00	0.000E+00	0.000E+00	6.99E-01
PAE	23	0.000E+00	0.000E+00	0.000E+00	6.99E-01
PAF	24	0.000E+00	0.000E+00	0.000E+00	6.99E-01
PAG	25	0.000E+00	0.000E+00	0.000E+00	6.99E-01
PAH	26	0.000E+00	0.000E+00	0.000E+00	6.99E-01
PAI	27	0.000E+00	0.000E+00	0.000E+00	6.99E-01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	6.99E-01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	1.97E+07	7.12E-03

Bromodichloromethane

CRU 5 FS
Initial Mass and Concentration

Compound Type	Org	
Kd Vadose 1	4.21E−01	ml/g
Kd Vadose 2	7.94E−02	ml/g
Rd Vadose 1	5.61E+00	
Rd Vadose 2	1.72E+00	
Screening Level	4.01E−03	mg/l
Lambda	1.00E−50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	0.000E+00	0.000E+00	0.000E+00	4.30E−01
560B	2	0.000E+00	0.000E+00	0.000E+00	4.25E−01
560C	3	0.000E+00	0.000E+00	0.000E+00	4.30E−01
560D	4	0.000E+00	0.000E+00	0.000E+00	4.21E−01
570A−S	5	0.000E+00	0.000E+00	0.000E+00	4.32E−01
570B	6	0.000E+00	0.000E+00	0.000E+00	4.40E−01
570C	7	0.000E+00	0.000E+00	0.000E+00	4.21E−01
570D	8	0.000E+00	0.000E+00	0.000E+00	4.21E−01
570E	9	0.000E+00	0.000E+00	0.000E+00	4.40E−01
575A	10	6.000E−03	8.721E+03	1.426E−02	4 30E−01
575B	11	0.000E+00	0.000E+00	0.000E+00	4.40E−01
580A	12	0.000E+00	0.000E+00	0.000E+00	4.30E−01
581A	13	0.000E+00	0.000E+00	0.000E+00	4.21E−01
581B	14	0.000E+00	0.000E+00	0.000E+00	4.21E−01
581C	15	0.000E+00	0.000E+00	0.000E+00	4.09E−01
581D	16	0.000E+00	0.000E+00	0.000E+00	4.21E−01
582A	17	0.000E+00	0.000E+00	0.000E+00	4.09E−01
582B	18	0.000E+00	0.000E+00	0.000E+00	4.21E−01
PAA	19	0.000E+00	0.000E+00	0.000E+00	4.21E−01
PAB	20	0.000E+00	0.000E+00	0.000E+00	4.21E−01
PAC	21	0.000E+00	0.000E+00	0.000E+00	4.21E−01
PAD	22	0.000E+00	0.000E+00	0.000E+00	4.21E−01
PAE	23	0.000E+00	0.000E+00	0.000E+00	4.21E−01
PAF	24	0.000E+00	0.000E+00	0.000E+00	4.21E−01
PAG	25	0.000E+00	0.000E+00	0.000E+00	4.21E−01
PAH	26	0.000E+00	0.000E+00	0.000E+00	4.21E−01
PAI	27	0.000E+00	0.000E+00	0.000E+00	4.21E−01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	4.21E−01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	9.42E+06	5.67E−03

Carbazole

CRU 5 FS

Initial Mass and Concentration

Compound Type	Org–S	
Kd Vadose 1	1.08E+01	ml/g
Kd Vadose 2	2.04E+00	ml/g
Rd Vadose 1	1.19E+02	
Rd Vadose 2	1.95E+01	
Screening Level	1.14E–02	mg/l
Lambda	1.00E–50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	0.000E+00	0.000E+00	0.000E+00	1.11E+01
560B	2	0.000E+00	0.000E+00	0.000E+00	1.09E+01
560C	3	0.000E+00	0.000E+00	0.000E+00	1.11E+01
560D	4	0.000E+00	0.000E+00	0.000E+00	1.08E+01
570A–S	5	0.000E+00	0.000E+00	0.000E+00	1.11E+01
570B	6	0.000E+00	0.000E+00	0.000E+00	1.13E+01
570C	7	0.000E+00	0.000E+00	0.000E+00	1.08E+01
570D	8	0.000E+00	0.000E+00	0.000E+00	1.08E+01
570E	9	0.000E+00	0.000E+00	0.000E+00	1.13E+01
575A	10	7.000E–03	1.017E+04	6.475E–04	1.11E+01
575B	11	0.000E+00	0.000E+00	0.000E+00	1.13E+01
580A	12	7.000E–03	1.017E+04	6.475E–04	1.11E+01
581A	13	0.000E+00	0.000E+00	0.000E+00	1.08E+01
581B	14	0.000E+00	0.000E+00	0.000E+00	1.08E+01
581C	15	0.000E+00	0.000E+00	0.000E+00	1.05E+01
581D	16	0.000E+00	0.000E+00	0.000E+00	1.08E+01
582A	17	0.000E+00	0.000E+00	0.000E+00	1.05E+01
582B	18	0.000E+00	0.000E+00	0.000E+00	1.08E+01
PAA	19	0.000E+00	0.000E+00	0.000E+00	1.08E+01
PAB	20	0.000E+00	0.000E+00	0.000E+00	1.08E+01
PAC	21	0.000E+00	0.000E+00	0.000E+00	1.08E+01
PAD	22	0.000E+00	0.000E+00	0.000E+00	1.08E+01
PAE	23	0.000E+00	0.000E+00	0.000E+00	1.08E+01
PAF	24	0.000E+00	0.000E+00	0.000E+00	1.08E+01
PAG	25	0.000E+00	0.000E+00	0.000E+00	1.08E+01
PAH	26	0.000E+00	0.000E+00	0.000E+00	1.08E+01
PAI	27	0.000E+00	0.000E+00	0.000E+00	1.08E+01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	1.08E+01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	2.47E+08	5.78E–03

000193

1,2-dichloroethane

CRU 5 FS

Initial Mass and Concentration

Compound Type	Org	
Kd Vadose 1	1.56E-01	ml/g
Kd Vadose 2	2.95E-02	ml/g
Rd Vadose 1	2.71E+00	
Rd Vadose 2	1.27E+00	
Screening Level	7.85E-04	mg/l
Lambda	9.50E-04	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	0.000E+00	0.000E+00	0.000E+00	1.60E-01
560B	2	0.000E+00	0.000E+00	0.000E+00	1.58E-01
560C	3	0.000E+00	0.000E+00	0.000E+00	1.60E-01
560D	4	0.000E+00	0.000E+00	0.000E+00	1.56E-01
570A-S	5	0.000E+00	0.000E+00	0.000E+00	1.60E-01
570B	6	0.000E+00	0.000E+00	0.000E+00	1.63E-01
570C	7	0.000E+00	0.000E+00	0.000E+00	1.56E-01
570D	8	0.000E+00	0.000E+00	0.000E+00	1.56E-01
570E	9	0.000E+00	0.000E+00	0.000E+00	1.63E-01
575A	10	0.000E+00	0.000E+00	0.000E+00	1.60E-01
575B	11	0.000E+00	0.000E+00	0.000E+00	1.63E-01
580A	12	0.000E+00	0.000E+00	0.000E+00	1.60E-01
581A	13	0.000E+00	0.000E+00	0.000E+00	1.56E-01
581B	14	0.000E+00	0.000E+00	0.000E+00	1.56E-01
581C	15	0.000E+00	0.000E+00	0.000E+00	1.52E-01
581D	16	0.000E+00	0.000E+00	0.000E+00	1.56E-01
582A	17	0.000E+00	0.000E+00	0.000E+00	1.52E-01
582B	18	0.000E+00	0.000E+00	0.000E+00	1.56E-01
PAA	19	0.000E+00	0.000E+00	0.000E+00	1.56E-01
PAB	20	0.000E+00	0.000E+00	0.000E+00	1.56E-01
PAC	21	0.000E+00	0.000E+00	0.000E+00	1.56E-01
PAD	22	0.000E+00	0.000E+00	0.000E+00	1.56E-01
PAE	23	0.000E+00	0.000E+00	0.000E+00	1.56E-01
PAF	24	0.000E+00	0.000E+00	0.000E+00	1.56E-01
PAG	25	0.000E+00	0.000E+00	0.000E+00	1.56E-01
PAH	26	0.000E+00	0.000E+00	0.000E+00	1.56E-01
PAI	27	0.000E+00	0.000E+00	0.000E+00	1.56E-01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	1.56E-01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	9.30E+06	1.51E-02

4-nitroaniline

CRU 5 FS

Initial Mass and Concentration

Compound Type	Org	
Kd Vadose 1	1.36E-01	ml/g
Kd Vadose 2	2.56E-02	ml/g
Rd Vadose 1	2.49E+00	
Rd Vadose 2	1.23E+00	
Screening Level	1.52E-02	mg/l
Lambda	1.00E-50	1/day

Waste Area	Waste Area Number	Constituent Concentration (mg/kg)	Constituent Mass per Block (mg)	Kd based Initial Concentration (mg/l)	Kd Layer 1 (ml/g)
560A	1	0.000E+00	0.000E+00	0.000E+00	1.39E-01
560B	2	3.300E-01	1.599E+05	2.430E+00	1.37E-01
560C	3	0.000E+00	0.000E+00	0.000E+00	1.39E-01
560D	4	0.000E+00	0.000E+00	0.000E+00	1.36E-01
570A-S	5	0.000E+00	0.000E+00	0.000E+00	1.40E-01
570B	6	0.000E+00	0.000E+00	0.000E+00	1.42E-01
570C	7	0.000E+00	0.000E+00	0.000E+00	1.36E-01
570D	8	0.000E+00	0.000E+00	0.000E+00	1.36E-01
570E	9	0.000E+00	0.000E+00	0.000E+00	1.42E-01
575A	10	0.000E+00	0.000E+00	0.000E+00	1.39E-01
575B	11	0.000E+00	0.000E+00	0.000E+00	1.42E-01
580A	12	0.000E+00	0.000E+00	0.000E+00	1.39E-01
581A	13	0.000E+00	0.000E+00	0.000E+00	1.36E-01
581B	14	0.000E+00	0.000E+00	0.000E+00	1.36E-01
581C	15	0.000E+00	0.000E+00	0.000E+00	1.32E-01
581D	16	0.000E+00	0.000E+00	0.000E+00	1.36E-01
582A	17	0.000E+00	0.000E+00	0.000E+00	1.32E-01
582B	18	0.000E+00	0.000E+00	0.000E+00	1.36E-01
PAA	19	0.000E+00	0.000E+00	0.000E+00	1.36E-01
PAB	20	0.000E+00	0.000E+00	0.000E+00	1.36E-01
PAC	21	0.000E+00	0.000E+00	0.000E+00	1.36E-01
PAD	22	0.000E+00	0.000E+00	0.000E+00	1.36E-01
PAE	23	0.000E+00	0.000E+00	0.000E+00	1.36E-01
PAF	24	0.000E+00	0.000E+00	0.000E+00	1.36E-01
PAG	25	0.000E+00	0.000E+00	0.000E+00	1.36E-01
PAH	26	0.000E+00	0.000E+00	0.000E+00	1.36E-01
PAI	27	0.000E+00	0.000E+00	0.000E+00	1.36E-01
WPAA	28	0.000E+00	0.000E+00	0.000E+00	1.36E-01

Surface Water Loading (Kg/yr)	CD	DE	EF	SSOD
	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Mass (mg)	Co (mg/L)
WPAOU1	0.00E+00	0.00E+00
WPAOU4	0.00E+00	0.00E+00
Solid Waste Landfill	0.00E+00	0.00E+00
Active Flyash Pile	0.00E+00	0.00E+00
Lime Sludge Ponds	0.00E+00	0.00E+00
South Field and Inactive Flyash Pile	0.00E+00	0.00E+00
Perched Water	0.00E+00	0.00E+00
Disposal Cell	1.13E+06	2.10E-03

ATTACHMENT H.II

AIR TRANSPORT MODELING

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H.II AIR TRANSPORT MODELING

This attachment presents the approach, methodology, and results of the CRARE air transport analysis. The objective of this analysis was to determine the maximum on-property, fenceline, and off-property annual average ground-level air concentrations of contaminants released to the atmosphere from the remediated FEMP. These concentrations were used for the CRARE residual risk assessment.

The analysis was conducted in accordance with EPA guidance (RAGS, EPA 1989a). Two emission models and an air dispersion model were used to estimate air emissions from each source and to calculate annual average concentrations at several preselected receptor locations. One emission model predicted the quantity of exposed soil that would be resuspended by the wind, and the other emission model estimated the flux of Rn-222 gas from soil containing Ra-226. Particulate-phase contaminants examined include radionuclides, inorganic compounds, and semivolatile and nonvolatile organic compounds. The air dispersion model accounted for dispersion and dilution of the contaminants under defined site-specific meteorological conditions, such as wind speed and direction, atmospheric stability, and mixing height. All meteorological data were collected from an on-property meteorological station, except mixing heights, which are from the National Weather Service in Dayton, Ohio.

Five major steps were required to achieve the objective of this analysis:

- Scenarios for the air transport analysis were defined.
- Sources of air emissions and contaminants released were identified based on site-specific information.
- The appropriate EPA regulatory air dispersion model was selected which best represented the site characteristics and the objective of the analysis.
- Particulate or gaseous air emissions were estimated from site-specific soil contaminant concentrations, and additional inputs to the model such as meteorological data and receptor locations were determined.
- Results of the air dispersion model were processed to determine the maximum on- and off-property annual average concentration for receptor exposures.

Figure H.II-1 presents the sequence of these steps and the sections below that describe them.

Throughout the analysis, site-specific data were used where available. When such data were not available, conservative assumptions were made. Regulatory default options and values were used where applicable in the air emission and dispersion models. The intent of the assumptions was to

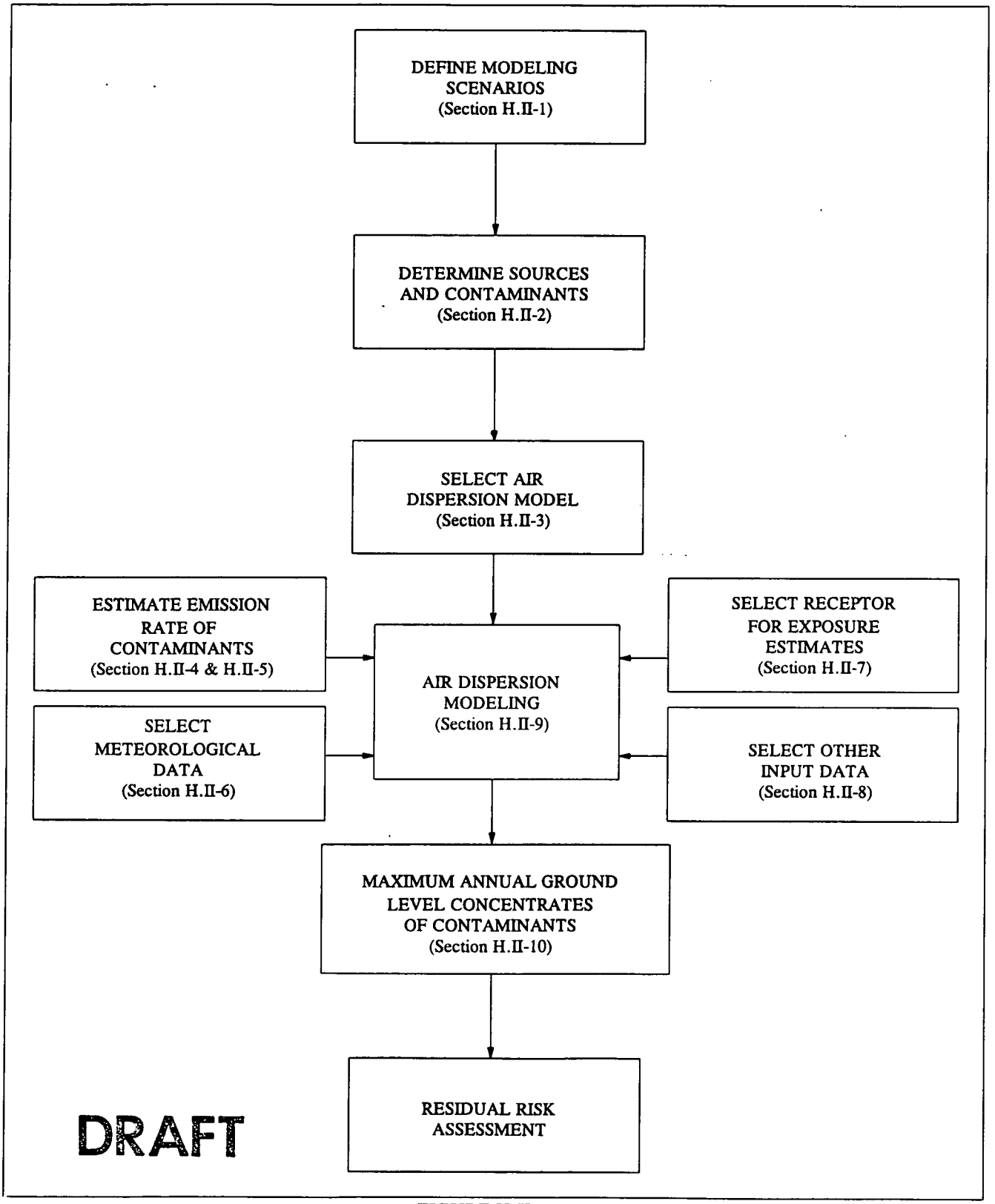

FIGURE H.II-1.
SEQUENTIAL BLOCK DIAGRAM OF AIR TRANSPORT ANALYSIS

make the results conservative and relevant to the site so that the risk associated with the air exposure pathway would not be underestimated.

H.II.1 SOURCE TERM ASSUMPTIONS FOR AIR TRANSPORT ANALYSIS

The air pathway fate and transport analysis was conducted assuming that exposed soil contaminant concentrations were less than or equal to the PRLs for a recreational user in an undeveloped park. The PRL value for each COC was developed to meet an ILCR of 10^{-6} or an HQ of 0.2, above background.

Several assumptions were made to develop source term emission rates for each operable unit. From the air transport analysis previously performed for the Operable Unit 4 CRARE (DOE 1993a), one can determine that no significant emissions occur from the disposal facilities or capped/covered areas, compared to emissions from exposed soil with residual contamination. Therefore, no air emission source terms were included for contaminants beneath the Operable Unit 1 cover or the disposal cell cap. The erosion of caps and cover soils caused by wind is less than 4 inches over the 1000-year period. This erosion rate is based on the total suspended particulate matter emission rate determined in Section H.II.4 and an assumed soil density of 1.5 g/cm^3. Combined with the erosion rate from surface water runoff, the total loss of caps and cover soils would not cause exposure of the contaminated layers in these areas.

Particulate matter and radon emissions were estimated for exposed soil in Operable Units 1, 2, 4, and 5. The materials and soil imported for cap layers and cover soil were assumed to be uncontaminated and would have contaminant concentrations at background levels. All excavated areas were assumed to be backfilled. The contaminant concentrations in these areas were also assumed to be at background levels. Statistical analyses were conducted on the samples remaining in the unexcavated areas. The results of the statistical analyses were used to characterize soil concentrations in the areas that were not excavated.

For this CRARE, the residual concentrations of uranium isotopes and total uranium were based on the average uranium composition on the site and the residual U-238 concentration in each source area. The approximate compositions are 0.00896, 0.685, 0.0093, and 99.3 percent (by weight) of U-234, U-235, U-236, and U-238, respectively.

H.II.2 SOURCE GROUPS

All emission sources considered for this study were analyzed as ground-level area sources. For this CRARE, 1306 square area sources were analyzed, covering on-property FEMP soils. These individual sources range in size from 2500 to 160,000 square feet. The emission sources included the exposed soils in Operable Units 1, 2, 4, and 5. To analyze emission impacts, 1306 area sources were

evaluated in 37 source groups. All sources within a given source group were assumed to have identical contaminant emission rates. Figure H.II-2 shows the source group locations and sizes used in the air dispersion model for areas associated with Operable Units 1 through 5. The 1306 area sources were combined into the following source groups:

Former Production Area - Sources

- PAa (8 sources)
- PAb (16 sources)
- PAc (10 sources)
- PAd (5 sources)
- PAe (15 sources)
- PAf (15 sources)
- PAg (10 sources)
- PAh (61 sources)
- PAi (43 sources)
- Waste Pits (8 sources)
- Active Flyash Pile (83 sources)
- South Field/Inactive Flyash Pile (278 sources)
- Solid Waste Landfill (4 sources)
- Lime Sludge Ponds (4 sources)
- OU4 Surface Soil (10 sources)
- FEMP Northeast Corner - East (36 sources)
- FEMP Northeast Corner - North (14 sources)

OU5 Surface Area - Sources

- 560a (108 sources)
- 560b (51 sources)
- 560c (8 sources)
- 560d (5 sources)
- 570a-North (37 sources)
- 570a-South (18 sources)
- 570b (14 sources)
- 570c (6 sources)
- 570d (18 sources)
- 570e (22 sources)
- 575a (56 sources)
- 575b (11 sources)
- 580a (27 sources)
- 581a (140 sources)
- 581b (75 sources)
- 581c (34 sources)
- 581d (12 sources)
- 582a (62 sources)
- 582b (16 sources)
- WPAa (49 sources)

The majority of these source groups were developed from the surface water runoff model source areas presented in Appendix F of the Operable Unit 5 RI report (DOE 1994a). This approach was selected because surface soil is assumed to be the source of contamination in both air and surface water pathways. For this CRARE, some modifications were made to the source groups originally developed for the Operable Unit 5 RI report. Area 570a and the FEMP northeast corner were each split into two groups to account for partial excavation of these areas.

For the undeveloped-park scenario, the areas which were not excavated included Area 560a, 570a-South, 575a, 575b, 580a, 582a, PAi, and NE Corner - North. The remaining areas were excavated sufficiently to assume that residual concentrations were at background levels.

The previous discussion of sources and source groups strictly pertains to modeling of on-property contaminant transport. Operable Unit 5 is also responsible for existing off-property contamination from previous FEMP operations. The existing off-property contamination is assumed to impact the off-property target receptors (resident farmer adult and child). Resuspension of off-property contaminated soil and subsequent inhalation by these target receptors were also modeled in this

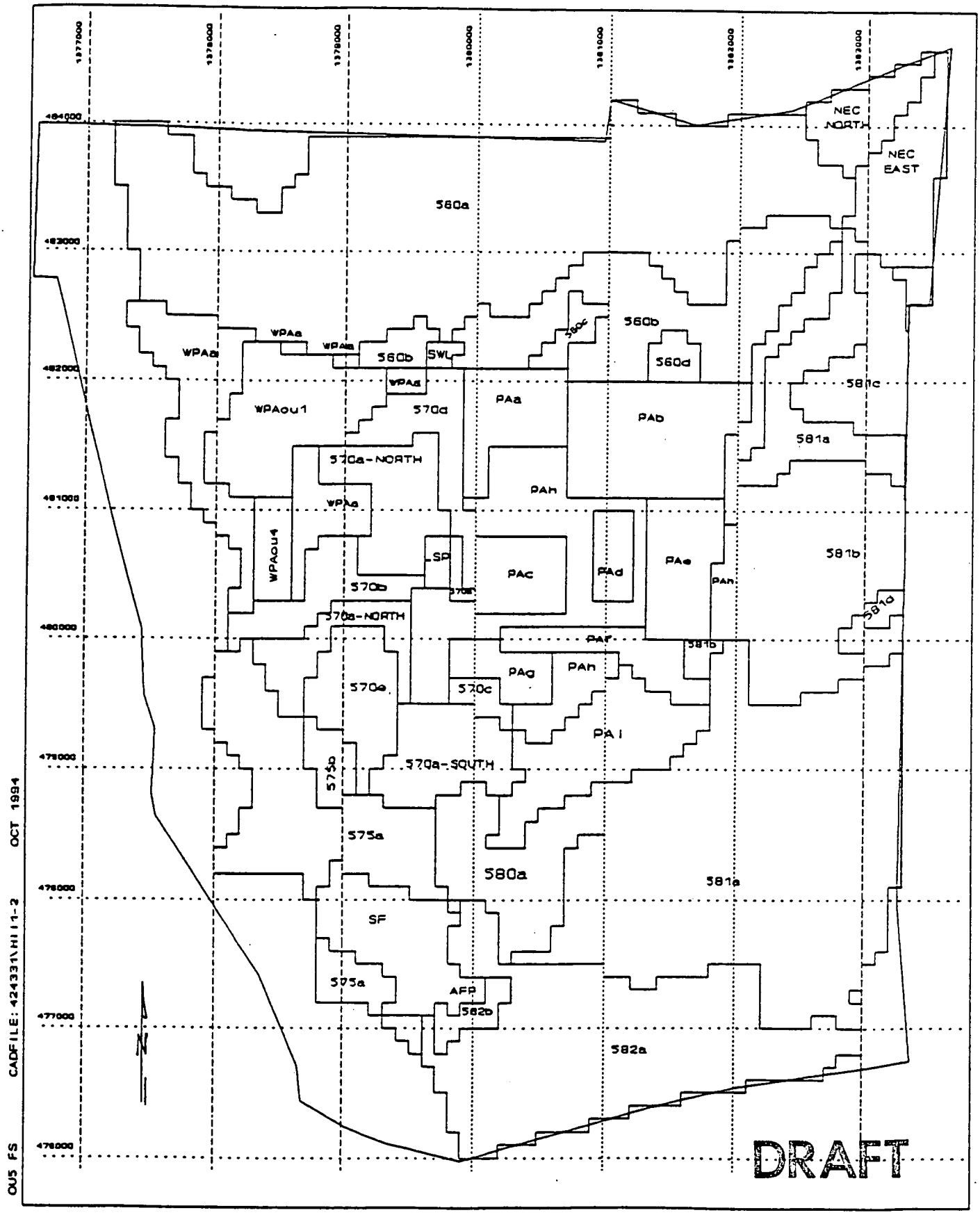

FIGURE H.II-2. SOURCE LOCATIONS FOR AIR DISPERSION MODEL

CRARE. The air modeling source group for the off-property contamination was represented by 49 square area sources making up a farm of approximately 20 acres. Each area source was 125 feet on a side.

H.II.3 AIR TRANSPORT MODELS

The annual average contaminant concentrations were determined using the Industrial Source Complex - Long Term, Version 2 (ISCLT2) dispersion model (EPA 1992a). This model is recommended by the EPA for air pathway analysis of Superfund sites (EPA 1989a). The ISCLT2 model was designed by the EPA to assess the air quality impact of emissions from a wide variety of sources. It incorporates a steady-state Gaussian plume equation that is applicable in flat or gently rolling terrain, for multiple point, area, and volume sources. The ISCLT2 model calculates the annual average concentration due to airborne emissions at user-selected receptors, based on sector-averaged statistical wind summaries. Data required for input to the model include source emission rates, the locations and configurations of sources, statistical summaries of wind speed, wind direction, and atmospheric stability, and the locations of the selected receptors. A description of the air models is presented in Table H.II-1.

TABLE H.II-1

MAJOR COMPONENTS OF THE AIR EMISSION AND DISPERSION MODELING

Model	Description and Use
RAECOM	RAECOM is a computer model developed by the U.S. Nuclear Regulatory Commission (NRC 1984) to simulate the emission of Rn-222 gas from soil and material containing Ra-226. RAECOM was used in this modeling effort to estimate the Rn-222 emission rate from FEMP surface soils and through cover soils placed over on-property consolidation areas. The output from RAECOM is used as input to ISCLT2.
Particulate Matter Emission Equations	The Particulate Matter Emission Equations are also presented in *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites* (EPA 1985). These equations are used in this modeling effort to estimate particulate matter emissions from surface soil caused by wind erosion. The results from these equations are used as input to ISCLT2.
ISCLT2	ISCLT2 is a computer model developed by the EPA (EPA 1992) to simulate the dispersion of gas-phase and particulate-phase contaminants emitted to the atmosphere. ISCLT2 is used in this modeling effort to predict the airborne concentrations and deposition rates of contaminants emitted from the FEMP surface soils. The output from RAECOM and particulate matter emission models are used as input to ISCLT2.

H.II.4 PARTICULATE CONTAMINANT EMISSION RATES

Radionuclide, inorganic, and organic contaminants were assumed to be present in the residual soil and in the suspended particulate matter emitted from the site. The emission rate for each contaminant in this particulate matter was calculated from the concentration of the contaminant in the exposed soil and from the estimated site-wide average emission rate of particulate matter less than 10 micrometers in diameter (PM_{10}). The emission rate of total suspended particulates (TSP) was estimated by assuming that PM_{10} emissions represented 50 percent of TSP emissions (EPA 1993a). The TSP emission rate was used to estimate deposition rates of contaminants onto soils and crops.

H.II.4.1 Contaminated Soil Concentrations

The estimated residual radionuclide, inorganic, and organic concentrations used for development of emission source terms are presented in Tables H.II-2 through H.II-4, respectively. Contaminant soil concentrations were selected from data in the RI/FS database and data presented in the Operable Unit 5 RI Report (DOE 1994a).

In this CRARE, cleanup levels were based on PRLs developed for the entire site. Because this analysis assumed that the site has been remediated, any soil with concentrations exceeding an applicable PRL will be excavated; therefore, concentrations in excavated areas were reset to the background levels. The background surface soil concentrations used in this CRARE, presented in Table H.II-5, are from the Operable Unit 5 RI report (DOE 1994a). The estimated, typical off-property soil concentrations used to analyze impacts to the off-property target receptors are presented in Table H.II-6.

H.II.4.2 Suspended Particulate Emission Estimate

The method used to estimate PM_{10} emission rates for the FEMP is based on EPA guidance for estimating wind erosion rates from flat soil surfaces at hazardous waste sites (EPA 1985a). This guidance has also been adopted by EPA for Superfund sites (EPA 1992b). The EPA methodology assumes that a minimum wind speed is required for the suspension of respirable dust. The emission rate is a nonlinear function of the "threshold friction velocity" (TFV) and the erosion potential of the site, which depends on the particle size distribution of the soil. Very fine soils (those with small modal diameters) have low TFVs and high potential for erosion by wind.

In addition to modal diameter, other factors such as the amount of nonerodible elements (gravel and pebbles with diameters greater than approximately 1 centimeter), the rustiness of the surface soil, and the amount of vegetative cover affect the quantity of soil that can be resuspended by the wind.

A review of the EPA method for determining the aerodynamic modal diameter of surface soil (EPA 1985a) indicated that additional laboratory sieve analyses needed to be conducted on FEMP soil to estimate this diameter. Therefore, a sampling protocol was developed based on the EPA guidance, and surface soil samples were collected and analyzed during May 1994 (FERMCO 1994a). The sampling protocol and analysis results were previously presented in the Operable Unit 2 FS report (DOE 1994b), Appendix I (CRARE). The measured aerodynamic modal diameters ranged from 2 to 4 millimeters.

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TABLE H.II-2

RESIDUAL RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL

	Radionuclide Concentrations, Including Background (pCi/g)						
Source Group	Ra-226	Sr-90	Tc-99	Th-230	Th-232	U-235/236	U-238
560a	9.23×10^{-1}	6.38×10^{-1}	2.50×10^{-1}	1.83×10^{0}	9.69×10^{-1}	1.88×10^{-2}	4.02×10^{0}
560b	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
560c	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
560d	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
570a-North	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
570a-South	1.23×10^{0}	4.11×10^{-1}	2.50×10^{-1}	2.67×10^{0}	8.19×10^{-1}	2.89×10^{-2}	6.20×10^{0}
570b	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
570c	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
570d	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
570e	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
575a	5.00×10^{0}	2.50×10^{-1}	2.50×10^{-1}	5.00×10^{0}	2.16×10^{0}	3.98×10^{-2}	8.55×10^{0}
575b	1.82×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.77×10^{0}	8.00×10^{-1}	3.71×10^{-2}	7.95×10^{0}
580a	5.00×10^{0}	3.56×10^{-1}	2.50×10^{-1}	5.00×10^{0}	9.05×10^{-1}	1.87×10^{-2}	4.00×10^{0}
581a	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
581b	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
581c	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
581d	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
582a	2.97×10^{0}	7.63×10^{-1}	2.50×10^{-1}	5.00×10^{0}	1.21×10^{0}	7.78×10^{-2}	1.67×10^{1}
582b	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
WPAa	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
NEbEast	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}

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TABLE H.I-2
(Continued)

Source Group	Radionuclide Concentrations, Including Background (pCi/g)						
	Ra-226	Sr-90	Tc-99	Th-230	Th-232	U-235/236	U-238
NEbNorth	9.11×10^{-1}	4.22×10^{-1}	2.50×10^{-1}	1.76×10^{0}	1.14×10^{0}	2.71×10^{-2}	5.82×10^{0}
WPAOU1	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
SF	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
AFP	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
SWL	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
LSP	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
WPAOU4	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
PAa	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
PAb	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
PAc	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
PAd	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
PAe	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
PAf	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
PAg	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
PAh	1.22×10^{0}	2.50×10^{-1}	2.50×10^{-1}	1.50×10^{0}	1.08×10^{0}	9.00×10^{-2}	1.08×10^{0}
PAi	1.62×10^{0}	4.70×10^{-1}	2.50×10^{-1}	2.26×10^{0}	9.23×10^{-1}	7.78×10^{-2}	1.67×10^{1}

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TABLE H.II-3

RESIDUAL INORGANIC CONCENTRATIONS IN SURFACE SOIL

Source Group	Inorganic Concentrations, Including Background (mg/kg)								
	Antimony	Arsenic	Beryllium	Cadmium	Magnesium	Manganese	Mercury	Silver	Uranium - Total
560a	6.92×10^{0}	4.13×10^{0}	5.25×10^{-1}	7.36×10^{-1}	6.09×10^{3}	8.97×10^{2}	5.97×10^{-2}	1.95×10^{0}	1.21×10^{1}
560b	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
560c	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
560d	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
570a-North	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
570a-South	1.25×10^{0}	6.38×10^{0}	5.36×10^{-1}	9.20×10^{-1}	1.37×10^{4}	6.46×10^{2}	8.04×10^{-2}	5.08×10^{-1}	1.86×10^{1}
570b	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
570c	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
570d	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
570e	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
575a	6.26×10^{0}	6.49×10^{0}	9.58×10^{-1}	8.74×10^{-1}	1.94×10^{4}	1.04×10^{3}	5.50×10^{-2}	7.10×10^{-1}	2.56×10^{1}
575b	1.20×10^{0}	6.20×10^{0}	6.32×10^{-1}	6.63×10^{-1}	1.02×10^{4}	1.15×10^{3}	5.50×10^{-2}	4.70×10^{-1}	2.38×10^{1}
580a	1.20×10^{0}	8.84×10^{0}	1.00×10^{0}	6.77×10^{-1}	1.67×10^{4}	5.90×10^{2}	5.78×10^{-2}	4.73×10^{-1}	1.20×10^{1}
581a	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
581b	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
581c	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
581d	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
582a	1.94×10^{0}	8.39×10^{0}	1.21×10^{0}	5.97×10^{-1}	5.70×10^{3}	4.84×10^{2}	6.13×10^{-2}	6.37×10^{-1}	5.00×10^{1}
582b	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
WPAa	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}

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TABLE H.II-3
(Continued)

Source Group	Inorganic Concentrations, Including Background (mg/kg)								
	Antimony	Arsenic	Beryllium	Cadmium	Magnesium	Manganese	Mercury	Silver	Uranium - Total
NEbEast	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
NEbNorth	1.29×10^{0}	5.67×10^{0}	4.17×10^{-1}	4.91×10^{-1}	2.12×10^{3}	1.29×10^{3}	5.73×10^{-2}	1.30×10^{0}	1.74×10^{1}
WPAOU1	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
SF	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
AFP	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
SWL	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
LSP	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
WPAOU4	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
PAa	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
PAb	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
PAc	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
PAd	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
PAe	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
PAf	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
PAg	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
PAh	3.65×10^{0}	5.56×10^{0}	6.00×10^{-1}	5.20×10^{-1}	1.93×10^{3}	8.14×10^{2}	3.00×10^{-1}	2.20×10^{0}	3.27×10^{0}
PAi	1.65×10^{0}	7.46×10^{0}	5.95×10^{-1}	7.47×10^{-1}	1.62×10^{4}	8.37×10^{2}	8.86×10^{-2}	1.08×10^{0}	5.00×10^{1}

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TABLE H.II-4

RESIDUAL ORGANIC CONCENTRATIONS IN SURFACE SOIL

	Organic Concentrations, Including Background (mg/kg)		
Area	Araclor-1254	Benzo(a)pyrene	Trichloroethane
560a	6.84×10^{-2}	2.00×10^{-2}	1.85×10^{-3}
560b	0.00	2.00×10^{-2}	0.00
560c	0.00	2.00×10^{-2}	0.00
560d	0.00	2.00×10^{-2}	0.00
570a-North	0.00	2.00×10^{-2}	0.00
570a-South	3.70×10^{-1}	2.00×10^{-2}	2.93×10^{-3}
570b	0.00	2.00×10^{-2}	0.00
570c	0.00	2.00×10^{-2}	0.00
570d	0.00	2.00×10^{-2}	0.00
570e	0.00	2.00×10^{-2}	0.00
575a	4.64×10^{-2}	2.00×10^{-2}	2.12×10^{-3}
575b	7.64×10^{-2}	2.00×10^{-2}	2.19×10^{-3}
580a	4.79×10^{-2}	2.00×10^{-2}	2.29×10^{-3}
581a	0.00	2.00×10^{-2}	0.00
581b	0.00	2.00×10^{-2}	0.00
581c	0.00	2.00×10^{-2}	0.00
581d	0.00	2.00×10^{-2}	0.00
582a	2.09×10^{-2}	2.00×10^{-2}	1.90×10^{-3}
582b	0.00	2.00×10^{-2}	0.00
WPAa	0.00	2.00×10^{-2}	0.00
NEbEast	0.00	2.00×10^{-2}	0.00
NEbNorth	2.12×10^{-2}	2.00×10^{-2}	1.93×10^{-3}
WPAOU1	0.00	2.00×10^{-2}	0.00
SF	0.00	2.00×10^{-2}	0.00
AFP	0.00	2.00×10^{-2}	0.00
SWL	0.00	2.00×10^{-2}	0.00
LSP	0.00	2.00×10^{-2}	0.00
WPAOU4	0.00	2.00×10^{-2}	0.00
PAa	0.00	2.00×10^{-2}	0.00

TABLE H.II-4 (Continued)

	Organic Concentrations, Including Background (mg/kg)		
Area	Araclor-1254	Benzo(a)pyrene	Trichloroethane
PAb	0.00	2.00×10^{-2}	0.00
PAc	0.00	2.00×10^{-2}	0.00
PAd	0.00	2.00×10^{-2}	0.00
PAe	0.00	2.00×10^{-2}	0.00
PAf	0.00	2.00×10^{-2}	0.00
PAg	0.00	2.00×10^{-2}	0.00
PAh	0.00	2.00×10^{-2}	0.00
PAi	4.50×10^{-2}	2.00×10^{-2}	0.00

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TABLE H.II-5

BACKGROUND COC CONCENTRATIONS IN SURFACE SOIL

COC	Representative Background Concentration
Radionuclides (pCi/g)	
Ra-226	1.22×10^{0}
Sr-90	2.50×10^{-1}
Tc-99	0.00
Th-230	1.50×10^{0}
Th-232	1.08×10^{0}
U-235/236	9.00×10^{-2}
U-238	1.08×10^{0}
Inorganics (mg/kg)	
Antimony	3.65×10^{0}
Arsenic	5.56×10^{0}
Beryllium	6.00×10^{-1}
Cadmium	5.20×10^{-1}
Magnesium	1.93×10^{3}
Manganese	8.14×10^{2}
Mercury	2.50×10^{-1}
Silver	2.20×10^{0}
Uranium - Total	3.27×10^{0}

TABLE H.II-6

OFF-PROPERTY COC CONCENTRATIONS IN SURFACE SOIL

COC	Representative Soil Concentration
Radionuclides (pCi/g)	
Ra-226	9.00×10^{-1}
Sr-90	2.65×10^{-1}
Tc-99	2.50×10^{-1}
Th-230	1.77×10^{0}
Th-232	8.88×10^{-1}
U-235/236	1.12×10^{-1}
U-238	2.40×10^{0}
Inorganics (mg/kg)	
Antimony	1.30×10^{0}
Arsenic	3.79×10^{0}
Beryllium	4.49×10^{-1}
Cadmium	4.90×10^{-1}
Magnesium	2.19×10^{3}
Manganese	6.47×10^{2}
Mercury	5.50×10^{-2}
Silver	4.80×10^{-1}
Uranium - Total	7.20×10^{0}
Organics (mg/kg)	
Araclor-1254	2.20×10^{-2}
Benzo(a)pyrene	2.00×10^{-2}
Trichlorethane	2.00×10^{-3}

Using an exposed soil modal diameter of 2 to 4 millimeters, the TFV can be determined from the EPA guidance document (EPA 1985a). The relationship between the modal diameter and the TFV is represented by the equation:

$$\log (TFV) = 1.812 + 0.4161 \log (d_p) \qquad \text{(H.II-1)}$$

where

TFV = threshold friction velocity (cm/s) near the soil surface and
d_p = modal diameter of soil sample (mm).

The calculated TFV ranges from 86.5 to 115 cm/s based on modal diameters of 2 to 4 millimeters. The calculated TFV should be corrected based on the surface roughness, rustiness, and quantity of nonerodible elements. The ratio of the corrected TFV to the uncorrected TFV is a nonlinear function of the ratio of the silhouette area of the roughness elements to the total area of bare loose soil (EPA 1985a). For this CRARE, no correction was applied to the calculated TFV based on the assumption that the exposed surface would behave in the same manner as dry, loose silt. This assumption is obviously conservative since the site has enough clay in the soil to form a nonerodible crust, the surface contains nonerodible elements, and the vegetation present will significantly increase the TFV necessary to resuspend surface soil.

The calculated TFV is greater then the 75 cm/s (30 in./s); therefore, the FEMP surface soil was considered to have a "limited" erosion potential (EPA 1985a). The equation for respirable particulate emissions from erosion of soils with limited erosion potential takes the following form:

$$E_{10} = 0.83 \times f \times P(u^+) \times (1 - V) / (PE/50)^2 \qquad \text{(H.II-2)}$$

where

E_{10} = annual average PM_{10} emission rate per unit area of contaminated surface ($mg/hr/m^2$),
f = frequency of disturbance per month,
$P(u^+)$ = erosion potential, the quantity of erodible particles present on the surface prior to the onset of wind erosion (g/m^2),
u^+ = observed (or probable) fastest mile of wind for the period between disturbances (m/s),
V = fraction of soil covered by vegetation, and
PE = Thorntwaite's Precipitation Index (measure of average soil moisture content).

The erosion potential in Equation H.II-2 depends on the fastest mile as follows (EPA 1985a):

$$P(u^+) = 6.7 \times (u^+ - u_t), \text{ for } u^+ \geq u_t, \text{ or} \qquad \text{(H.II-3)}$$
$$= 0, \text{ for } u^+ < u_t.$$

A typical fastest mile for the region is 24 m/s (EPA 1985a) at 7 meters above ground. The TFV must be corrected to the anemometer height (7 meters) used to collect the fastest mile data. The corrected TFV is calculated from the following equation (EPA 1985a):

$$u_t/TFV = (1/0.4)\ 1n\ (Z/Z_o) \qquad \text{(H.II-4)}$$

where

Z = anemometer height (m) and
Z_o = surface roughness height (m).

The surface at the FEMP is now, and will be, covered with grass and other vegetation after completion of remedial actions. Using an approximated value of 0.03 m for grassland (EPA 1985a) as Z_o, the value of u_t was calculated to be 11.8 to 15.7 m/s. The calculated values for $P(u^+)$ range from 81.8 down to 55.4 g/m^2 for aerodynamic modal diameters of 2 to 4 millimeters, respectively.

The frequency of disturbance represents the frequency that the surface crust is broken by mechanical means, such as agricultural tilling. For the undeveloped-park scenario, the only disturbance caused by the recreational user was assumed to be from walking across the site. Over a 70-year period, the park user spends 6140 hours on site. The park user was assumed to walk at a pace of 3 miles per hour and was assumed to disturb a path 1 foot wide. Therefore, the total area disturbed over the 70-year period is approximately 2233 acres, or approximately 32 acres per year. Dividing this area by the total area of the site (1050 acres) results in a value for f of 0.0304.

Currently, the FEMP is 80 to 85 percent covered with vegetation (DOE 1993b). After remediation, the site will be planted with appropriate vegetation for erosion control and aesthetics. The region easily supports plant life, and a 100 percent vegetative cover can be expected over the postremedial site, with or without continued maintenance. For this air transport analysis, the site was conservatively assumed to be 85 percent covered with vegetation. The 85 percent value is in line with EPA estimates of control efficiencies for vegetative covers (EPA 1987a).

The erosion potential of PM_{10} for the FEMP under the adopted site wide alternative ranged from 1.40 x 10^{-8} to 2.03 x 10^{-8} g/s/m^2 for aerodynamic modal diameters of 4 and 2 millimeters, respectively. The larger value was used in contaminant emission rate calculations.

The contaminant surface soil concentration in each area was multiplied by the annual average PM_{10} emission flux to determine the contaminant-specific emission rate used in the model for calculating airborne concentrations. The contaminant surface soil concentration was multiplied by the annual average TSP emission flux to determine the contaminant-specific emission rate used for calculating total deposition rates. Total particulate matter contaminant emissions for each source group are presented in Tables H.II-7 through H.II-9. Background particulate matter contaminant emission rates are presented in Table H.II-10.

TABLE H.II-7

RESIDUAL RADIONUCLIDE EMISSION RATES

Source Group	Radionuclide Emission Rates, Including Background (pCi/s/m^2)						
	Ra-226	Sr-90	Tc-99	Th-230	Th-232	U-235/236	U-238
560a	1.87×10^{-8}	1.29×10^{-8}	5.08×10^{-9}	3.72×10^{-8}	1.97×10^{-8}	3.81×10^{-10}	8.17×10^{-8}
560b	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
560c	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
560d	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
570a-North	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
570a-South	2.50×10^{-8}	8.35×10^{-9}	5.08×10^{-9}	5.42×10^{-8}	1.66×10^{-8}	5.87×10^{-10}	1.26×10^{-7}
570b	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
570c	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
570d	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
570e	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
575a	1.02×10^{-7}	5.08×10^{-9}	5.08×10^{-9}	1.02×10^{-7}	4.38×10^{-8}	8.09×10^{-10}	1.73×10^{-7}
575b	3.68×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.58×10^{-8}	1.62×10^{-8}	7.53×10^{-10}	1.61×10^{-7}
580a	1.02×10^{-7}	7.24×10^{-9}	5.08×10^{-9}	1.02×10^{-7}	1.84×10^{-8}	3.79×10^{-10}	8.12×10^{-8}
581a	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
581b	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
581c	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
581d	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
582a	6.03×10^{-8}	1.55×10^{-8}	5.08×10^{-9}	1.02×10^{-7}	2.45×10^{-8}	1.58×10^{-9}	3.39×10^{-7}
582b	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
WPAa	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
NEbEast	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}

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TABLE H.II-7
(Continued)

Source Group	Radionuclide Emission Rates, Including Background (pCi/s/m²)						
	Ra-226	Sr-90	Tc-99	Th-230	Th-232	U-235/236	U-238
NEbNorth	1.85×10^{-8}	8.56×10^{-9}	5.08×10^{-9}	3.56×10^{-8}	2.31×10^{-8}	5.51×10^{-10}	1.18×10^{-7}
WPAOU1	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
SF	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
AFP	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
SWL	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
LSP	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
WPAOU4	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
PAa	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
PAb	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
PAc	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
PAd	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
PAe	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
PAf	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
PAg	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
PAh	2.48×10^{-8}	5.08×10^{-9}	5.08×10^{-9}	3.05×10^{-8}	2.19×10^{-8}	1.83×10^{-9}	2.19×10^{-8}
PAi	3.28×10^{-8}	9.54×10^{-9}	5.08×10^{-9}	4.59×10^{-8}	1.87×10^{-8}	1.58×10^{-9}	3.39×10^{-7}

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TABLE H.II-8

RESIDUAL INORGANIC EMISSION RATES

Source Group	Inorganic Emission Rates, Including Background ($\mu g/s/m^2$)								
	Antimony	Arsenic	Beryllium	Cadmium	Magnesium	Manganese	Mercury	Silver	Uranium - Total
560a	1.40×10^{-7}	8.39×10^{-8}	1.07×10^{-8}	1.49×10^{-8}	1.24×10^{-4}	1.82×10^{-5}	1.21×10^{-9}	3.95×10^{-8}	2.45×10^{-7}
560b	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
560c	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
560d	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
570a-North	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
570a-South	2.55×10^{-8}	1.30×10^{-7}	1.09×10^{-8}	1.87×10^{-8}	2.78×10^{-4}	1.31×10^{-5}	1.63×10^{-9}	1.03×10^{-8}	3.77×10^{-7}
570b	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
570c	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
570d	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
570e	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
575a	1.27×10^{-7}	1.32×10^{-7}	1.94×10^{-8}	1.78×10^{-8}	3.93×10^{-4}	2.10×10^{-5}	1.12×10^{-9}	1.44×10^{-8}	5.20×10^{-7}
575b	2.44×10^{-8}	1.26×10^{-7}	1.28×10^{-8}	1.34×10^{-8}	2.08×10^{-4}	2.34×10^{-5}	1.12×10^{-9}	9.54×10^{-9}	4.84×10^{-7}
580a	2.44×10^{-8}	1.79×10^{-7}	2.03×10^{-8}	1.38×10^{-8}	3.39×10^{-4}	1.20×10^{-5}	1.17×10^{-9}	9.59×10^{-9}	2.43×10^{-7}
581a	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
581b	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
581c	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
581d	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
582a	3.94×10^{-8}	1.70×10^{-7}	2.46×10^{-8}	1.21×10^{-8}	1.16×10^{-4}	9.82×10^{-6}	1.24×10^{-9}	1.29×10^{-8}	1.02×10^{-6}
582b	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
WPAa	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}

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TABLE H.II-8
(Continued)

Source Group	Inorganic Emission Rates, Including Background ($\mu g/s/m^2$)								
	Antimony	Arsenic	Beryllium	Cadmium	Magnesium	Manganese	Mercury	Silver	Uranium - Total
NEbEast	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
NEbNorth	2.61×10^{-8}	1.15×10^{-7}	8.46×10^{-9}	9.97×10^{-9}	4.29×10^{-5}	2.61×10^{-5}	1.16×10^{-9}	2.64×10^{-8}	3.54×10^{-7}
WPAOU1	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
SF	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
AFP	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
SWL	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
LSP	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
WPAOU4	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
PAa	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
PAb	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
PAc	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
PAd	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
PAe	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
PAf	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
PAg	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
PAh	7.41×10^{-8}	1.13×10^{-7}	1.22×10^{-8}	1.06×10^{-8}	3.92×10^{-5}	1.65×10^{-5}	6.09×10^{-9}	4.47×10^{-8}	6.64×10^{-8}
PAi	3.35×10^{-8}	1.51×10^{-7}	1.21×10^{-8}	1.52×10^{-8}	3.29×10^{-4}	1.70×10^{-5}	1.80×10^{-9}	2.20×10^{-8}	1.02×10^{-6}

TABLE H.II-9

RESIDUAL ORGANIC EMISSION RATES

	Organic Emission Rates, Including Background ($\mu g/s/m^2$)		
Source Group	Aroclor-1254	Benzo(a)pyrene	Trichloroethane
560a	1.39×10^{-9}	4.06×10^{-10}	3.76-11
560b	0.00	4.06×10^{-10}	0.00
560c	0.00	4.06×10^{-10}	0.00
560d	0.00	4.06×10^{-10}	0.00
570a-North	0.00	4.06×10^{-10}	0.00
570a-South	7.52×10^{-9}	4.06×10^{-10}	5.95×10^{-11}
570b	0.00	4.06×10^{-10}	0.00
570c	0.00	4.06×10^{-10}	0.00
570d	0.00	4.06×10^{-10}	0.00
570e	0.00	4.06×10^{-10}	0.00
575a	9.41×10^{-10}	4.06×10^{-10}	4.30×10^{-11}
575b	1.55×10^{-9}	4.06×10^{-10}	4.44×10^{-11}
580a	9.73×10^{-10}	4.06×10^{-10}	4.65×10^{-11}
581a	0.00	4.06×10^{-10}	0.00
581b	0.00	4.06×10^{-10}	0.00
581c	0.00	4.06×10^{-10}	0.00
581d	0.00	4.06×10^{-10}	0.00
582a	4.24×10^{-10}	4.06×10^{-10}	3.85×10^{-11}
582b	0.00	4.06×10^{-10}	0.00
WPAa	0.00	4.06×10^{-10}	0.00
NEbEast	0.00	4.06×10^{-10}	0.00
NEbNorth	4.31×10^{-10}	4.06×10^{-10}	3.92×10^{-11}
WPAOU1	0.00	4.06×10^{-10}	0.00
SF	0.00	4.06×10^{-10}	0.00
AFP	0.00	4.06×10^{-10}	0.00
SWL	0.00	4.06×10^{-10}	0.00
LSP	0.00	4.06×10^{-10}	0.00
WPAOU4	0.00	4.06×10^{-10}	0.00
PAa	0.00	4.06×10^{-10}	0.00

TABLE H.II-9
(Continued)

Source Group	Organic Emission Rates, Including Background ($\mu g/s/m^2$)		
	Aroclor-1254	Benzo(a)pyrene	Trichloroethane
PAb	0.00	4.06×10^{-10}	0.00
PAc	0.00	4.06×10^{-10}	0.00
PAd	0.00	4.06×10^{-10}	0.00
PAe	0.00	4.06×10^{-10}	0.00
PAf	0.00	4.06×10^{-10}	0.00
PAg	0.00	4.06×10^{-10}	0.00
PAh	0.00	4.06×10^{-10}	0.00
PAi	9.12×10^{-10}	4.06×10^{-10}	3.76×10^{-11}

TABLE H.II-10

BACKGROUND CONTAMINANT EMISSION RATES

Contaminant	Representative Background Emission Rate
Radionuclides (pCi/g)	
Ra-226	2.48×10^{-8}
Rn-222	3.27×10^{-1}
Sr-90	5.08×10^{-9}
Tc-99	0.00
Th-230	3.05×10^{-8}
Th-232	2.19×10^{-8}
U-235/236	1.83×10^{-9}
U-238	2.19×10^{-8}
Inorganics (mg/kg)	
Antimony	7.41×10^{-8}
Arsenic	1.13×10^{-7}
Beryllium	1.22×10^{-8}
Cadmium	1.06×10^{-8}
Magnesium	3.92×10^{-5}
Manganese	1.66×10^{-5}
Mercury	5.08×10^{-9}
Silver	4.47×10^{-8}
Uranium - Total	6.64×10^{-8}

H.II.5 GASEOUS CONTAMINANT EMISSION RATES

Emissions of Rn-222 were estimated for all exposed soil areas. Rn-222 emissions were determined from the Ra-226 concentrations in the contaminated soil using the RAECOM model algorithms developed for the NRC (NRC 1984). The model accounts for the half-lives of radon and radium as well as the density, porosity, moisture content, and depth of contaminated layers and cover layers in estimating Rn-222 emission rates. The model converts Ra-226 soil concentrations (in pCi/g) to Rn-222 fluxes (in pCi/s/m^2). The basic equations for estimating Rn-222 emissions from bare soil is presented below (NRC 1984):

$$J_t = 10^4 \, R\rho \, E\sqrt{\lambda D_t} \tanh\left(X_t\sqrt{\frac{\lambda}{D_t}}\right) \qquad \text{(H.II-1-5)}$$

where

J_t	=	radon flux from the soil surface (pCi/s/m^2),
R	=	activity concentration of Ra-226 in soil (pCi/g),
ρ	=	dry bulk density of soil (g/cm^3),
E	=	radon emanation coefficient (assumed to be 0.22 from NRC 1984),
λ	=	decay constant of radon (= 2.1 x 10^{-6} 1/s),
D_t	=	diffusion coefficient of radon in the total pore space (cm^2/s),
X_t	=	thickness of contaminated soil (assumed to be 300 cm for surface soil), and
10^4	=	conversion factor for m^2 to cm^2.

The RAECOM model input parameters and results are presented in Table H.II-11. The model output files are presented in Table H.II-12.

H.II.6 METEOROLOGICAL DATA

Meteorological data characterizing the transport and dispersion conditions of an area are needed as input to the ISCLT2 model. These data include wind speed, wind direction, atmospheric stability, ambient air temperature, and mixing height. Measurements for all of these meteorological parameters, except mixing height, have been recorded at the FEMP site as part of a comprehensive environmental monitoring program since August 1986.

Direct measurements of wind speed, wind direction, and ambient air temperature were taken at a height of 10 meters above the ground. Atmospheric stability was derived from direct measurements of the standard deviation of the horizontal wind direction (σ_θ) during the day and the low-level temperature difference (ΔT) at night. Measurements of σ_θ were taken at a height of 60 meters above the ground. The temperature difference was calculated from air temperature measurements taken at 60 and 10 meters above the ground. Site-specific hourly measurements were obtained for 1987 through 1992, excluding 1990 due to poor data recovery. A five-year composite joint frequency

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distribution of windspeed, wind direction, and atmospheric stability is presented in Table H.II-13. The composite distribution was used in the ISCLT2 dispersion model.

TABLE H.II-11

RAECOM MODEL INPUT PARAMETERS AND RESULTS

Source Group	Total Ra-226 Soil Conc. (pCi/g)	Soil Bulk Density (g/cm3)	Layer Thickness (cm)	Soil Porosity	Soil Moisture Content (dry Wt%)	Rn-222 Emission Rate (pCi/s/m²)
560a	0.92	1.44	45	0.457	16.9	0.2361
560b	1.22	1.44	45	0.457	16.9	0.3269
560c	1.22	1.44	45	0.457	16.9	0.3269
560d	1.22	1.44	45	0.457	16.9	0.3269
570a-North	1.22	1.44	45	0.457	16.9	0.3269
570a-South	1.23	1.44	45	0.457	16.9	0.3269
570b	1.22	1.44	45	0.457	16.9	0.3269
570c	1.22	1.44	45	0.457	16.9	0.3269
570d	1.22	1.44	45	0.457	16.9	0.3269
570e	1.22	1.44	45	0.457	16.9	0.3269
575a	5.00	1.44	45	0.457	16.9	1.340
575b	1.82	1.44	45	0.457	16.9	0.4722
580a	5.00	1.44	45	0.457	16.9	1.340
581a	1.22	1.44	45	0.457	16.9	0.3269
581b	1.22	1.44	45	0.457	16.9	0.3269
581c	1.22	1.44	45	0.457	16.9	0.3269
581d	1.22	1.44	45	0.457	16.9	0.3269
582a	2.97	1.44	45	0.457	16.9	0.781
582b	1.22	1.44	45	0.457	16.9	0.3269
WPAa	1.22	1.44	45	0.457	16.9	0.3269
NEb-East	1.22	1.44	45	0.457	16.9	0.3269
NEb-North	0.91	1.44	45	0.457	16.9	0.2361
WPAOU1	1.22	1.44	45	0.457	16.9	0.3269
SF	1.22	1.44	45	0.457	16.9	0.3269
AFP	1.22	1.44	45	0.457	16.9	0.3269
SWL	1.22	1.44	45	0.457	16.9	0.3269
LSP	1.22	1.44	45	0.457	16.9	0.3269

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TABLE H.II-11
(Continued)

Source Group	Total Ra-226 Soil Conc. (pCi/g)	Soil Bulk Density (g/cm3)	Layer Thickness (cm)	Soil Porosity	Soil Moisture Content (dry Wt%)	Rn-222 Emission Rate ($pCi/s/m^2$)
WPAOU4	1.22	1.44	45	0.457	16.9	0.3269
PAa	1.22	1.44	45	0.457	16.9	0.3269
PAb	1.22	1.44	45	0.457	16.9	0.3269
PAc	1.22	1.44	45	0.457	16.9	0.3269
PAd	1.22	1.44	45	0.457	16.9	0.3269
PAe	1.22	1.44	45	0.457	16.9	0.3269
PAf	1.22	1.44	45	0.457	16.9	0.3269
PAg	1.22	1.44	45	0.457	16.9	0.3269
PAh	1.22	1.44	45	0.457	16.9	0.3269
PAi	1.62	1.44	45	0.457	16.9	0.4359
Off-Property	0.90	1.44	45	0.457	16.9	0.2361

TABLE H.II-12
RAECOM MODEL OUTPUT

OU5 RESIDUAL EMISSIONS: Ra-226=0.92 pCi/g, 560a, NEb-North

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.2361	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt.%)
1	45.	$.1044 \times 10^{-1}$	.4570	$.1300 \times 10^{-5}$	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	$.2361 \times 10^{0}$	$.0000 \times 10^{0}$	.5988

TABLE H.II-12
(Continued)

OU5 RESIDUAL EMISSIONS: Ra-226=1.22 pCi/g, Background

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.3269	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt.%)
1	45.	$.1044 \times 10^{-1}$	.4570	$.1800 \times 10^{-5}$	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	$.3269 \times 10^{0}$	$.0000 \times 10^{0}$	.5988

TABLE H.II-12
(Continued)

OU5 RESIDUAL EMISSIONS: Ra-226=1.62 pCi/g, PAi

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.4359	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt.%)
1	45.	$.1044 \times 10^{-1}$	.4570	$.2400 \times 10^{-3}$	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	$.4359 \times 10^{0}$	$.0000 \times 10^{0}$	.5988

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TABLE H.II-12
(Continued)

OU5 RESIDUAL EMISSIONS: Ra-226=1.82 pCi/g, 575b

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.4722	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt.%)
1	45.	$.1044 \times 10^{-1}$	.4570	$.2600 \times 10^{-5}$	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	$.4722 \times 10^{0}$	$.0000 \times 10^{0}$	.5988

TABLE H.II-12
(Continued)

OU5 RESIDUAL EMISSIONS: Ra-226=2.97 pCi/g, 582a

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.7810	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt.%)
1	45.	$.1044 \times 10^{-1}$	.4570	$.4300 \times 10^{-3}$	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	$.7810 \times 10^{0}$	$.0000 \times 10^{0}$	.5988

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TABLE H.II-12
(Continued)

OU5 RESIDUAL EMISSIONS: Ra-226=5.00 pCi/g, 575a, 580a

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	1.340	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt.%)
1	45.	$.1044 \times 10^{-1}$	.4570	$.7269 \times 10^{-3}$	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	45.	$.1340 \times 10^{1}$	$.0000 \times 10^{0}$	.5988

TABLE H.II-13

FEMP STANDARD JOINT FREQUENCY DISTRIBUTION

Stability Class	Wind Direction	Wind Speed (kts) ≤3	≤6	≤10	≤16	≤21	≥21
A	N	0.000263	0.000904	0.000904	0.000058	0.000000	0.000000
	NNE	0.000292	0.001546	0.000671	0.000000	0.000000	0.000000
	NE	0.000817	0.002888	0.001196	0.000029	0.000000	0.000000
	ENE	0.001430	0.004434	0.002042	0.000117	0.000000	0.000000
	E	0.001050	0.002013	0.000204	0.000146	0.000000	0.000000
	ESE	0.000700	0.000817	0.000058	0.000000	0.000000	0.000000
	SE	0.000467	0.000438	0.000000	0.000000	0.000000	0.000000
	SSE	0.000583	0.000554	0.000000	0.000000	0.000000	0.000000
	S	0.000700	0.001575	0.001196	0.000000	0.000000	0.000000
	SSW	0.001021	0.004347	0.003793	0.000146	0.000000	0.000000
	SW	0.001284	0.005076	0.004755	0.000554	0.000000	0.000000
	WSW	0.001750	0.004755	0.003647	0.000204	0.000000	0.000000
	W	0.000992	0.003880	0.003267	0.000467	0.000000	0.000000
	WNW	0.000613	0.001809	0.002626	0.000525	0.000000	0.000000
	NW	0.000583	0.001575	0.001400	0.000117	0.000000	0.000000
	NNW	0.000350	0.001313	0.001284	0.000058	0.000000	0.000000
B	N	0.000029	0.000817	0.000700	0.000117	0.000000	0.000000
	NNE	0.000117	0.000525	0.000496	0.000058	0.000000	0.000000
	NE	0.000350	0.000963	0.000613	0.000058	0.000000	0.000000
	ENE	0.000321	0.001459	0.000554	0.000146	0.000000	0.000000
	E	0.000467	0.000671	0.000175	0.000029	0.000000	0.000000
	ESE	0.000263	0.000263	0.000029	0.000000	0.000000	0.000000
	SE	0.000233	0.000204	0.000029	0.000000	0.000000	0.000000
	SSE	0.000263	0.000467	0.000088	0.000029	0.000000	0.000000
	S	0.000408	0.001138	0.000321	0.000000	0.000000	0.000000
	SSW	0.000525	0.001546	0.001313	0.000175	0.000000	0.000000
	SW	0.000613	0.002042	0.002071	0.000233	0.000000	0.000000
	WSW	0.000613	0.001692	0.001284	0.000175	0.000000	0.000000
	W	0.000671	0.001167	0.001225	0.000146	0.000000	0.000000
	WNW	0.000233	0.000788	0.000875	0.000204	0.000000	0.000000
	NW	0.000263	0.000671	0.001021	0.000204	0.000000	0.000000
	NNW	0.000146	0.000642	0.000904	0.000088	0.000000	0.000000

TABLE H.II-13
(Continued)

Stability Class	Wind Direction	Wind Speed (kts) ≤3	≤6	≤10	≤16	≤21	≥21
C	N	0.000204	0.000846	0.001079	0.000233	0.000000	0.000000
	NNE	0.000175	0.001313	0.000729	0.000058	0.000000	0.000000
	NE	0.000408	0.001488	0.001021	0.000088	0.000000	0.000000
	ENE	0.000700	0.001721	0.000438	0.000263	0.000000	0.000000
	E	0.001050	0.000875	0.000204	0.000058	0.000000	0.000000
	ESE	0.000671	0.000583	0.000058	0.000000	0.000000	0.000000
	SE	0.000321	0.000467	0.000088	0.000000	0.000000	0.000000
	SSE	0.000146	0.000467	0.000058	0.000058	0.000000	0.000000
	S	0.000321	0.001167	0.000554	0.000058	0.000000	0.000000
	SSW	0.000554	0.001750	0.001575	0.000058	0.000029	0.000000
	SW	0.000904	0.002742	0.001750	0.000175	0.000000	0.000000
	WSW	0.000759	0.002421	0.001254	0.000204	0.000000	0.000000
	W	0.000788	0.001284	0.001138	0.000321	0.000000	0.000000
	WNW	0.000321	0.001342	0.001254	0.000204	0.000000	0.000000
	NW	0.000233	0.001342	0.001138	0.000117	0.000029	0.000000
	NNW	0.000233	0.001079	0.000963	0.000029	0.000000	0.000000
D	N	0.002101	0.008723	0.009219	0.001079	0.000000	0.000000
	NNE	0.002830	0.010532	0.008256	0.001138	0.000000	0.000000
	NE	0.004464	0.013420	0.007498	0.000496	0.000000	0.000000
	ENE	0.006331	0.017825	0.009161	0.002042	0.000000	0.000000
	E	0.004493	0.006127	0.001079	0.000088	0.000000	0.000000
	ESE	0.003238	0.002976	0.000117	0.000000	0.000000	0.000000
	SE	0.002626	0.002626	0.000350	0.000000	0.000000	0.000000
	SSE	0.002801	0.003618	0.001109	0.000204	0.000000	0.000000
	S	0.003063	0.006593	0.002888	0.000321	0.000000	0.000000
	SSW	0.005806	0.014091	0.007439	0.001809	0.000000	0.000000
	SW	0.007848	0.014470	0.008023	0.001050	0.000058	0.000000
	WSW	0.008373	0.011203	0.006272	0.001167	0.000000	0.000000
	W	0.007060	0.011553	0.009482	0.001430	0.000000	0.000000
	WNW	0.004785	0.010415	0.010619	0.001546	0.000000	0.000000
	NW	0.003734	0.009044	0.007264	0.000963	0.000088	0.000000
	NNW	0.002976	0.008840	0.005631	0.001050	0.000058	0.000000

TABLE H.II-13
(Continued)

Stability Class	Wind Direction	Wind Speed (kts) ≤3	≤6	≤10	≤16	≤21	≥21
E	N	0.003618	0.003880	0.000759	0.000029	0.000000	0.000000
	NNE	0.002596	0.003092	0.000788	0.000175	0.000000	0.000000
	NE	0.002976	0.003472	0.000438	0.000000	0.000000	0.000000
	ENE	0.008694	0.009219	0.001809	0.000000	0.000000	0.000000
	E	0.008198	0.002742	0.000233	0.000000	0.000000	0.000000
	ESE	0.004785	0.001254	0.000146	0.000000	0.000000	0.000000
	SE	0.004843	0.001721	0.000292	0.000000	0.000000	0.000000
	SSE	0.005572	0.003413	0.001284	0.000204	0.000000	0.000000
	S	0.006973	0.007673	0.003355	0.000642	0.000000	0.000000
	SSW	0.011582	0.014033	0.006798	0.001692	0.000000	0.000000
	SW	0.018496	0.018263	0.007410	0.000671	0.000000	0.000000
	WSW	0.017796	0.010328	0.003297	0.000642	0.000000	0.000000
	W	0.012486	0.010007	0.004143	0.000146	0.000000	0.000000
	WNW	0.009482	0.007614	0.003297	0.000583	0.000000	0.000000
	NW	0.008344	0.004668	0.001109	0.000175	0.000000	0.000000
	NNW	0.006214	0.003822	0.001079	0.000263	0.000000	0.000000
F	N	0.004988	0.000117	0.000000	0.000000	0.000000	0.000000
	NNE	0.005251	0.000088	0.000029	0.000000	0.000000	0.000000
	NE	0.005076	0.000117	0.000000	0.000000	0.000000	0.000000
	ENE	0.009102	0.001605	0.000117	0.000000	0.000000	0.000000
	E	0.013361	0.000904	0.000000	0.000000	0.000000	0.000000
	ESE	0.008927	0.000058	0.000000	0.000000	0.000000	0.000000
	SE	0.005922	0.000321	0.000000	0.000000	0.000000	0.000000
	SSE	0.005456	0.000175	0.000000	0.000000	0.000000	0.000000
	S	0.007002	0.000467	0.000000	0.000000	0.000000	0.000000
	SSW	0.011815	0.001196	0.000263	0.000000	0.000000	0.000000
	SW	0.019576	0.002101	0.000029	0.000000	0.000000	0.000000
	WSW	0.026811	0.001867	0.000058	0.000000	0.000000	0.000000
	W	0.029757	0.000671	0.000029	0.000000	0.000000	0.000000
	WNW	0.029319	0.000233	0.000029	0.000000	0.000000	0.000000
	NW	0.022785	0.000758	0.000058	0.000000	0.000000	0.000000
	NNW	0.011523	0.000876	0.000058	0.000000	0.000000	0.000000

Mixing heights were determined from twice daily atmospheric soundings made by the National Weather Service. The nearest station is in Dayton, Ohio.

H.II.7 RECEPTOR LOCATIONS

As previously stated, the objective of the air transport analysis was to determine the maximum on-and off-property contaminant concentrations for risk assessment calculations. Two rectangular receptor grid systems were used to determine the maximum on-property concentrations and approximate locations.

The first grid consisted of 676 receptor points in a 400 x 400 foot pattern which extended over the entire FEMP property. The 1927 State Planar coordinate system was used to identify receptor locations. The first grid extended from 1,375,000 feet east, 475,000 feet north to 1,385,000 feet east, 485,000 feet north. The second grid consisted of 360 receptor points also in a 400 x 400 foot pattern located over the center of the FEMP. The second grid was offset 200 feet north and 200 feet east of the first grid, resulting in an effective 283 x 283 foot pattern over the center of the FEMP. The second grid extended from 1,376,800 feet east, 476,000 feet north to 1,383,600 feet east, 483,600 feet north.

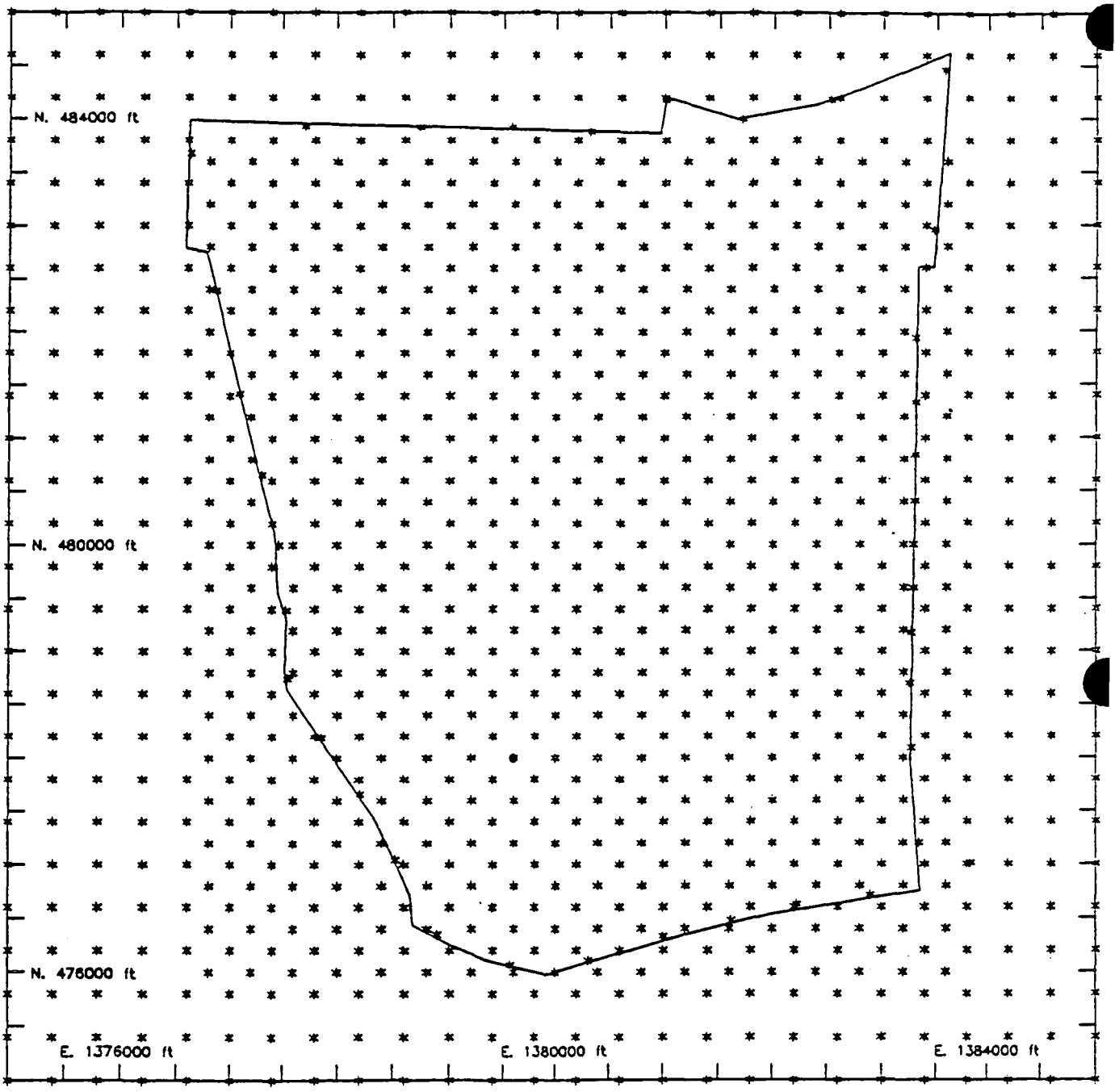
Thirty-six fenceline receptor points located around the FEMP were included in the air transport analysis to identify the maximum off-property receptor. These fenceline receptor locations were determined from the intersection of the FEMP fenceline and imaginary lines extending in 36 directions at 10-degree intervals from a point located at 1,381,000 feet east, 480,000 feet north. The analysis results for the fenceline receptor with the highest air quality impacts are reported as the maximum off-property concentrations in Section H.II.10.

Figure H.II-3 shows the layout of the receptor grid considered in the air dispersion modeling. Because the concentrations were used primarily to estimate the inhalation pathway risk for outdoor activities, the receptors were assumed to be 1.5 meters above the ground to simulate a typical person's breathing height for outdoor activities (EPA 1989b). The variation of ground level concentration within 0 to 1.5 meters is negligible.

In addition, an off-property grid of 196 receptor points were modeled over an approximately 20-acre farm. This grid was used to model the transport of off-property contaminated soil to the off-property target receptors.

H.II.8 DISPERSION COEFFICIENTS

The selection of rural or urban dispersion coefficients for use in the ISCLT2 model was based on a land-use typing procedure to determine whether the characteristics of the area around the FEMP are primarily rural or urban. The procedure involved classifying the land use within an area



DRAFT

* = Receptor Location

FIGURE H.II-3. RECEPTOR GRIDS FOR AIR DISPERSION MODELING

circumscribed by a 3-kilometer radius about the site. Urban dispersion coefficients were recommended for use if land-use types of heavy industrial, light-to-moderate industrial, commercial, single-compact residential, and multi-compact residential account for 50 percent or more of the area. Otherwise, rural dispersion coefficients were recommended.

A review of U.S. Geological Survey (USGS) maps and a site survey of the area indicated that industrial, commercial, and compact residential land use comprise no more than 10 percent of the area within a 3-kilometer radius of the site. Therefore, the area was classified as rural for the purpose of air dispersion modeling, indicating the use of rural dispersion coefficients would be appropriate.

H.II.9 MODEL OUTPUT PROCESSING

The air dispersion modeling analysis was simplified by running the ISCLT2 model with an assumed emission rate of 1.0 g/s/m^2 or 1.0 pCi/s/m^2 for each area source. The source group and plot file options of the ISCLT2 program were used to group sources with identical emission rates and write the grouped results to a plot file. The ISCLT2 source group results were multiplied by the contaminant emission rates listed in Tables H.II-7 through H.II-9 to determine the contaminant-specific annual concentrations presented in Section H.II.10. Spreadsheets were used to calculate the contaminant-specific air concentrations from the ISCLT2 model output and emissions data in Tables H.II-7 through H.II-9.

H.II.10 RESULTS OF AIR DISPERSION MODELING

This section presents the modeled air concentration for each COC. In addition, the modeled concentrations of several radionuclides are compared to the monitored air concentrations from previous years to determine the effectiveness of mitigation measures and to identify the magnitude of uncertainties in the analysis.

H.II.10.1 Modeled Air Concentrations

The modeled maximum annual average contaminant air concentrations are presented in Tables H.II-14 through H.II-16. The values presented in Table H.II-14 are the maximum on-property concentrations, and the values presented in Table H.II-15 are the fenceline concentrations. The modeled off-property air concentrations due to off-property soil contaminations are presented in Table H.II-16. Total and background air concentrations have been included on each table. Based on the results presented in the Operable Unit 4 CRARE, the maximum off-property concentrations were used to represent average on-property concentrations for receptors that were assumed to roam or wander over the property.

TABLE H.II-14

MAXIMUM ON-PROPERTY RESIDUAL COC CONCENTRATIONS IN AIR

	Concentrations in Air	
COC	Total	Background
Inorganics ($\mu g/m^3$)		
Antimony	2.79×10^{-6}	2.33×10^{-6}
Arsenic	3.86×10^{-6}	3.55×10^{-6}
Beryllium	4.56×10^{-7}	3.83×10^{-7}
Cadmium	3.91×10^{-7}	3.32×10^{-7}
Magnesium	5.71×10^{-3}	1.23×10^{-3}
Manganese	5.21×10^{-4}	5.19×10^{-4}
Mercury	1.71×10^{-7}	1.91×10^{-7}
Silver	1.32×10^{-6}	1.40×10^{-6}
Uranium - Total	1.16×10^{-5}	2.09×10^{-6}
Organics ($\mu g/m^3$)		
Aroclor-1254	5.27×10^{-8}	0.00
Benzo(a)pyrene	1.28×10^{-8}	0.00
Trichloroethene	7.70×10^{-10}	0.00
Radionuclides (pCi/m^3)		
Ra-226	1.57×10^{-6}	7.78×10^{-7}
Rn-222	2.20×10^{1}	1.13×10^{1}
Sr-90	2.38×10^{-7}	1.59×10^{-7}
Tc-99	1.59×10^{-7}	0.00
Th-230	1.80×10^{-6}	9.57×10^{-7}
Th-232	6.97×10^{-7}	6.89×10^{-7}
U-235/236	5.27×10^{-8}	5.74×10^{-8}
U-238	3.87×10^{-6}	6.89×10^{-7}

TABLE H.II-15

MAXIMUM FENCELINE RESIDUAL CONTAMINANT COCs CONCENTRATIONS IN AIR

	Concentrations in Air	
COC	Total	Background
Inorganics ($\mu g/m^3$)		
Antimony	2.02×10^{-6}	2.02×10^{-6}
Arsenic	3.16×10^{-6}	3.07×10^{-6}
Beryllium	3.46×10^{-7}	3.32×10^{-7}
Cadmium	3.03×10^{-7}	2.87×10^{-7}
Magnesium	1.84×10^{-3}	1.07×10^{-3}
Manganese	4.46×10^{-4}	4.50×10^{-4}
Mercury	1.48×10^{-7}	1.66×10^{-7}
Silver	1.13×10^{-6}	1.22×10^{-6}
Uranium - Total	1.07×10^{-5}	1.81×10^{-6}
Organics ($\mu g/m^3$)		
Aroclor-1254	1.58×10^{-8}	0.00
Benzo(a)pyrene	1.11×10^{-8}	0.00
Trichloroethene	4.42×10^{-10}	0.00
Radionuclides (pCi/m^3)		
Ra-226	8.16×10^{-7}	6.74×10^{-7}
Rn-222	1.13×10^{1}	9.46×10^{0}
Sr-90	1.86×10^{-7}	1.38×10^{-7}
Tc-99	1.38×10^{-7}	0.00
Th-230	1.25×10^{-6}	8.29×10^{-7}
Th-232	6.01×10^{-7}	5.97×10^{-7}
U-235/236	4.65×10^{-8}	4.97×10^{-8}
U-238	3.56×10^{-6}	5.97×10^{-7}

TABLE H.II-16

MAXIMUM OFF-PROPERTY RESIDUAL CONTAMINANT COCs IN AIR

	Concentrations in Air	
Contaminant	Total	Background
Inorganics ($\mu g/m^3$)		
Antimony	2.94×10^{-7}	8.24×10^{-7}
Arsenic	8.55×10^{-7}	1.26×10^{-6}
Beryllium	1.01×10^{-7}	1.35×10^{-7}
Cadmium	1.11×10^{-7}	1.17×10^{-7}
Magnesium	4.95×10^{-4}	4.36×10^{-4}
Manganese	1.46×10^{-4}	1.84×10^{-4}
Mercury	1.24×10^{-8}	6.77×10^{-8}
Silver	1.08×10^{-7}	4.97×10^{-7}
Uranium - Total	1.62×10^{-6}	7.38×10^{-7}
Organics ($\mu g/m^3$)		
Aroclor-1254	4.97×10^{-9}	0.00
Benzo(a)pyrene	4.51×10^{-9}	0.00
Trichloroethene	4.51×10^{-10}	0.00
Radionuclides (pCi/m^3)		
Ra-226	2.03×10^{-7}	2.75×10^{-7}
Rn-222	2.63×10^{0}	1.36×10^{1}
Sr-90	5.98×10^{-8}	5.64×10^{-8}
Tc-99	2.74×10^{-7}	0.00
Th-230	3.98×10^{-7}	3.39×10^{-7}
Th-232	2.00×10^{-7}	2.44×10^{-7}
U-235/236	2.53×10^{-8}	2.03×10^{-8}
U-238	5.42×10^{-7}	2.44×10^{-7}

000243

Modeled concentrations of U-238 represent typical particulate-phase radionuclide activity. The maximum total on-property and fenceline concentrations of U-238 were modeled at 3.87×10^{-6} and 3.56×10^{-6} pCi/m^3, respectively. Residual concentrations in air, above background, are 3.18×10^{-6} and 2.96×10^{-6} pCi/m^3, respectively, for maximum on-property and fenceline impacts. Isopleths of U-238 concentrations are presented on Figure H.II-4.

Modeled air concentrations of gaseous Rn-222 on property and at the fenceline are 22.0 and 11.3 pCi/m^3, respectively, based on total, residual Ra-226 soil concentrations. After correcting for background Ra-226 soil concentrations, the on-property and fenceline Rn-222 concentrations were modeled at 10.7 and 1.84 pCi/m^3, respectively. Isopleths of Rn-222 concentrations are presented in Figure H.II-5.

The total impacts to the off-property target receptors must include contributions from both on- and off-property residual contamination. The off-property contribution to the air pathway is represented in Table H.II-16. The contribution from on-property contamination must be estimated from the fenceline air concentrations. For this CRARE, the off-property farm was assumed to be located approximately 1200 feet east of the FEMP eastern fenceline (near an existing off-property water well). The on-property impacts to this location were determined by dividing the fenceline air concentration (Table H.II-15) by 2.3 to account for dispersion over distance (EPA 1992b). These results are added to the values in Table H.II-16 to determine the air pathway impact from on- and off-property contamination to the off-property target receptors.

H.II.10.2 Comparison to Monitored Air Concentrations

The maximum annual fenceline concentration of several radionuclides measured during 1991 and 1992 (DOE 1993c) are presented in Table H.II-17. A comparison of modeled future fenceline concentrations with currently measured values indicates that remediation of the site would reduce off-property air impacts by 1 to 2 orders of magnitude.

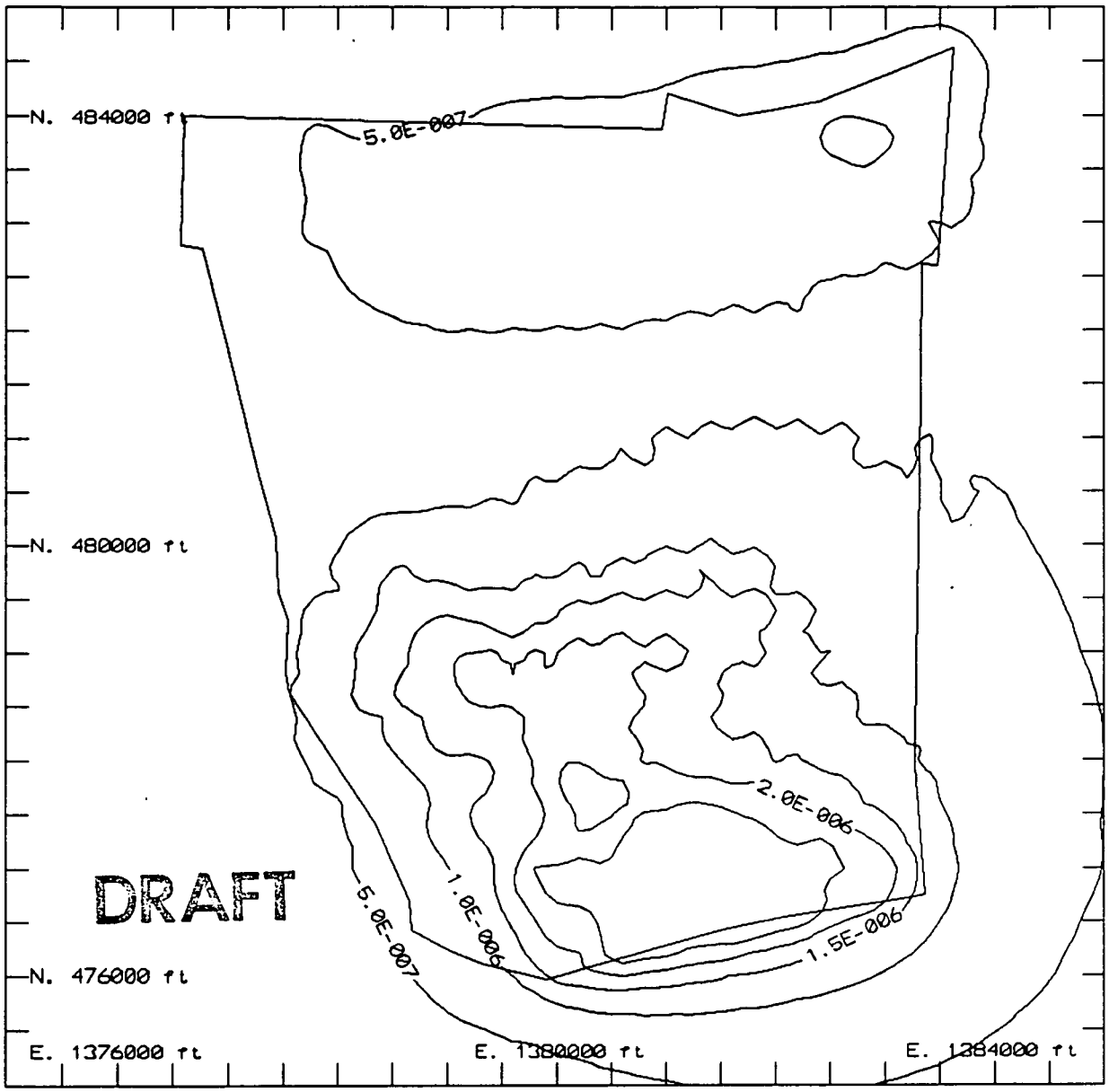


FIGURE H.II-4. RESIDUAL U-238 CONCENTRATION IN AIR (pCi/m^3)

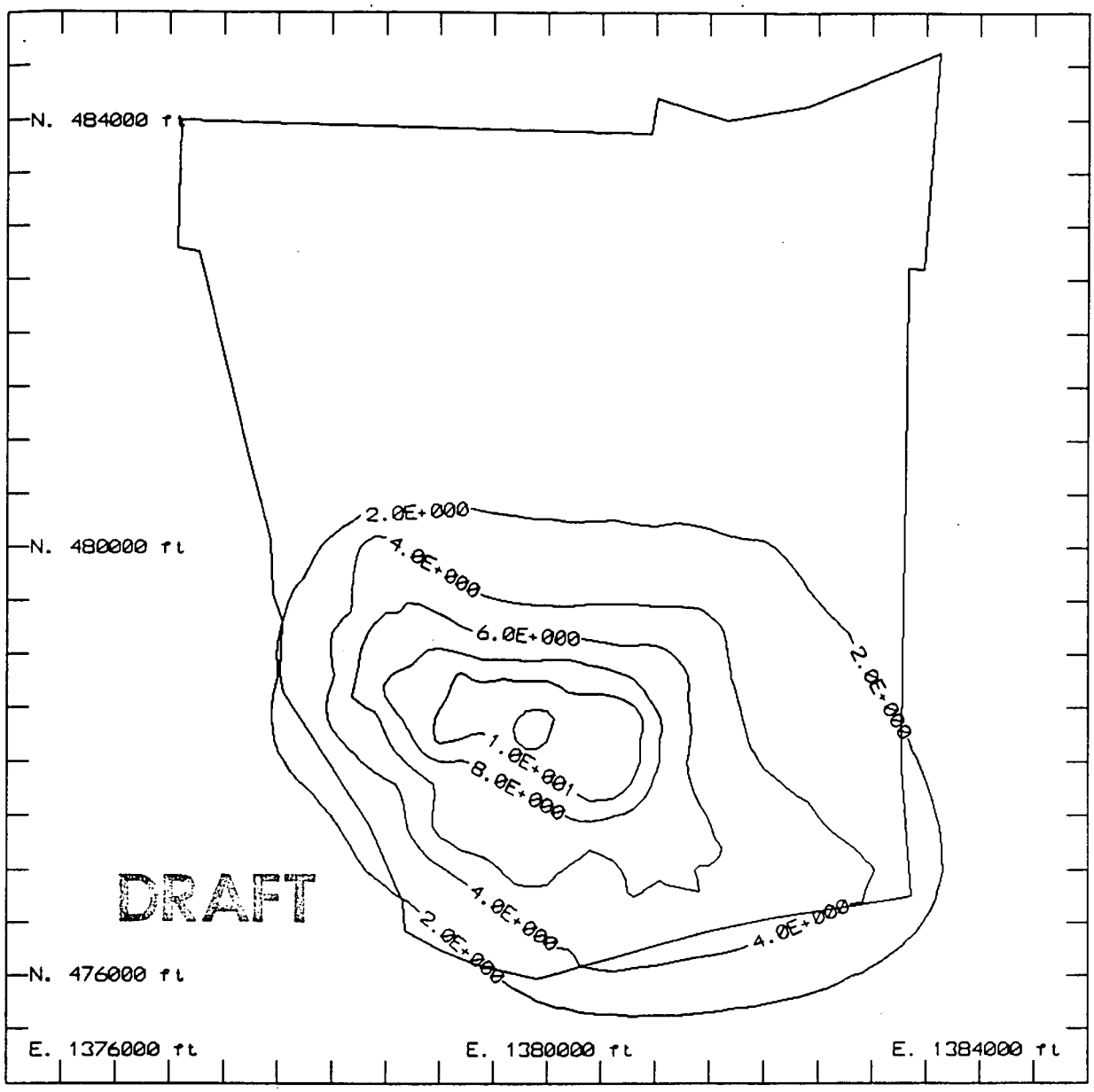


FIGURE H.II-5. RESIDUAL RN-222 CONCENTRATION IN AIR (pCi/m^3)

TABLE H.II-17

ANTICIPATED AIR COC CONCENTRATION AT FENCELINE AFTER COMPLETION OF REMEDIAL ACTIVITIES

Radionuclide	Modeled Conc. (pCi/m^3)	Monitored Conc. (pCi/m^3) 1991	Monitored Conc. (pCi/m^3) 1992	Anticipated Reduction (%)
Ra-226	8.16×10^{-7}	$< 5.9 \times 10^{-5}$	1.0×10^{-4}	98-99
Rn-222	1.13×10^{1}	3.1×10^{2}	1.7×10^{2}	93-96
Sr-90	1.86×10^{-7}	$< 7.8 \times 10^{-5}$	No Data	99
Tc-99	1.38×10^{-7}	1.5×10^{-5}	1.1×10^{-3}	99
Th-230	1.25×10^{-6}	2.1×10^{-5}	$< 3.3 \times 10^{-5}$	94-96
Th-232	6.01×10^{-7}	1.3×10^{-5}	$< 4.0 \times 10^{-5}$	95-98
U-235/236	4.65×10^{-8}	7.4×10^{-6}	5.4×10^{-6}	99
U-238	3.56×10^{-6}	1.2×10^{-4}	9.8×10^{-5}	96-97

Source: DOE 1993

LIST OF REFERENCES

Fernald Environmental Restoration Management Corporation (FERMCO), 1994a, Memorandum from M. Cherry, May 11, 1994, Subject: "Technical Direction and Clarification for Conducting Surface Soil Sampling."

U.S. Department of Energy (DOE), 1993a, "Operable Unit 4 Feasibility Study Report," Final, DOE, Fernald Field Office, Fernald, OH.

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U.S. Nuclear Regulatory Commission (NRC), 1994, "Radon Attenuation Handbook for Uranium Mill Tailing Cover Design," NUREG/CR-3533, NRC, Office of Nuclear Regulatory Research, Washington, DC.

ATTACHMENT H.II

Fernald Environmental
FERMCO
Restoration Management Corporation

INTEROFFICE MEMORANDUM

To:	Tom Anderson Cheri Smyser	**Date:**	May 11, 1994
Location:	Fernald, T-80	**Reference:**	
From:	Mark Cherry MJC	**FERMCO #:**	M:CRU5:94-0212
Location:	Fernald, T-80	**Client:**	DOE DE-AC05-920R21972
Extension:	738-6816	**Subject:**	Technical Direction and Clarification for Conducting Surface Soil Sampling

c: File Record Storage Copy 106.4.19

This memo provides technical direction and clarification for conducting surface soil sampling in support of air modeling for the baseline risk assessment.

- Samples should be collected from the seven locations identified on the attached map (Attachment 1).
- Surface soil sampling protocols outlined in the attached EPA procedure (Attachment 2) and Appendix K of the SCQ should be followed.
- All samples should be field screened for beta/gamma activity and recorded in the field log. A Radiation Technician should be present during all sampling activities.
- Samples should be transported to the FERMCO lab for sieving.
- Samples should be split at the lab into two equal fractions. One sample fraction should be sieved immediately and the other should be allowed to air dry for 24 hours prior to sieving.
- Samples should be sieved per the attached EPA procedure (Attachment 2).
- The health and safety requirements defined in the Health and Safety Plan for the Surface and Subsurface Soil Sampling Investigation (WBS No. 50.03.18, June 1993) as amended in the attached memo (Attachment 3) must be followed.

If you have any questions or require additional information, please contact me at your earliest convenience.

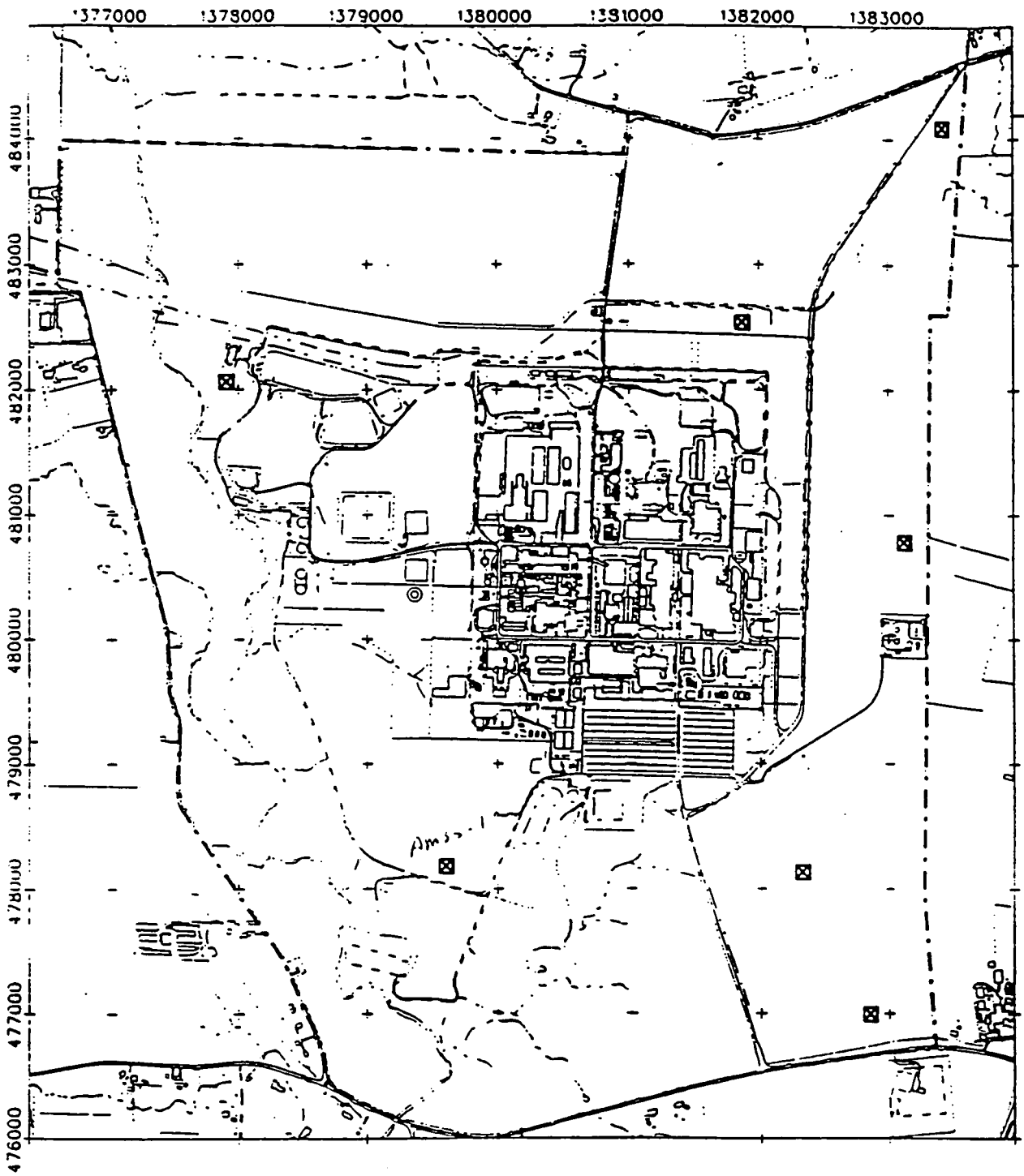


FIGURE 2-x. SURFACE SOIL SAMPLING LOCATIONS TO SUPPORT AIR PATHWAY MODELING

ATTACHMENT II

FIELD PROCEDURE FOR DETERMINATION OF THRESHOLD FRICTION VELOCITY*

1. Prepare a nest of sieves with the following openings: 4 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm. Place a collector pan below the bottom sieve (0.25 mm opening).

2. Collect a sample representing the surface layer of loose particles (approximately 1 cm in depth for an uncrusted surface), removing any rocks larger than about 1 cm in average physical diameter. The area to be sampled should not be less than 30 cm x 30 cm.

3. Pour the sample into the top sieve (4 mm opening), and place a lid on the top.

4. Rotate the covered sieve/pan unit by hand using broad sweeping arm motions in the horizontal plane. Complete 20 rotations at a speed just necessary to achieve some relative horizontal motion between the sieve and the particles.

5. Inspect the relative quantities of catch within each sieve and determine where the mode in the aggregate size distribution lies, i.e., between the opening size of the sieve with the largest catch and the opening size of the next largest sieve.

* Adapted from a laboratory procedure published by W. S. Chepil (1952).

ATTACHMENT #II

Fernald Environmental

FERMCO

Restoration Management Corporation

INTEROFFICE MEMORANDUM

To:	Greg Johnson	**Date:**	May 12, 1994
Location:	Fernald, T-80	**Reference:**	
From:	Mark Cherry MJC	**FERMCO #:**	M:CRU5:94-0216
Location:	Fernald, T-80	**Client:**	DOE DE-AC05-920R21972
Extension:	738-6816	**Subject:**	Health and Safety Plan

c: File Record Storage Copy 106.4.19
Tom Anderson
Cheri Smyser

The attached health and safety plan is applicable to the air model surface soil sampling with the following modifications:

- In reference to Section 13.1.1: Replace Art Bomberger with Dave Brettschneider as CRU5 Project Director; also, add Mark Cherry as CRU5 Project Manager.
- Replace item 1. on page 19 with the following statement:
  1. The project will consist of collecting soil samples in non-production areas of the FEMP. The soil will be collected at a depth interval of 0-3 inches (maximum).
- Replace item 2.b. on page 20 with the following statement:
  2.b. A RCT will accompany the samples during sampling activities. In addition, all sample team members will be radiological worker trained to the RAD II level.
- Delete item 2.e. on page 20 "Prior to the implementation of..."
- Add to item 2: The samplers shall take care to avoid poison ivy, bees and other bio-hazards; and shall check periodically for ticks.
- Page 24: Provide a map of the sampling locations.

Also attached is a memo describing the work to be performed. If you are in agreement with the terms of this memo, please sign on the line below.

Concurrence: Greg Johnson, CRU5 HSO

MJC:TAA:daz
Attachment

000254

RESULTS

ERNALD
RI/FS

FIELD ACTIVITY DAILY LOG

DAILY L NO. | SHEET OF 4

ROJECT NAME: SURFACE SOIL SAMPLING & AIR MODELING | PROJECT NO. N/A.

ELD ACTIVITY SUBJECT: SEVEN SS FOR OUS BASELINE RISK ASSESSMENT

ESCRIPTION ON DAILY ACTIVITIES AND EVENTS:

00 arrive at AMSS-2 which is located 30 feet northwest of MW cluster 1733. collect 1 gal ± surface soil sample (AMSS-2). see map below. this is the correct location of AMSS-2.

40 arrive at AMSS-3 which is located 50 feet north of lysimeters 11130/11131. collect 1 gal of the top cm surface soil.

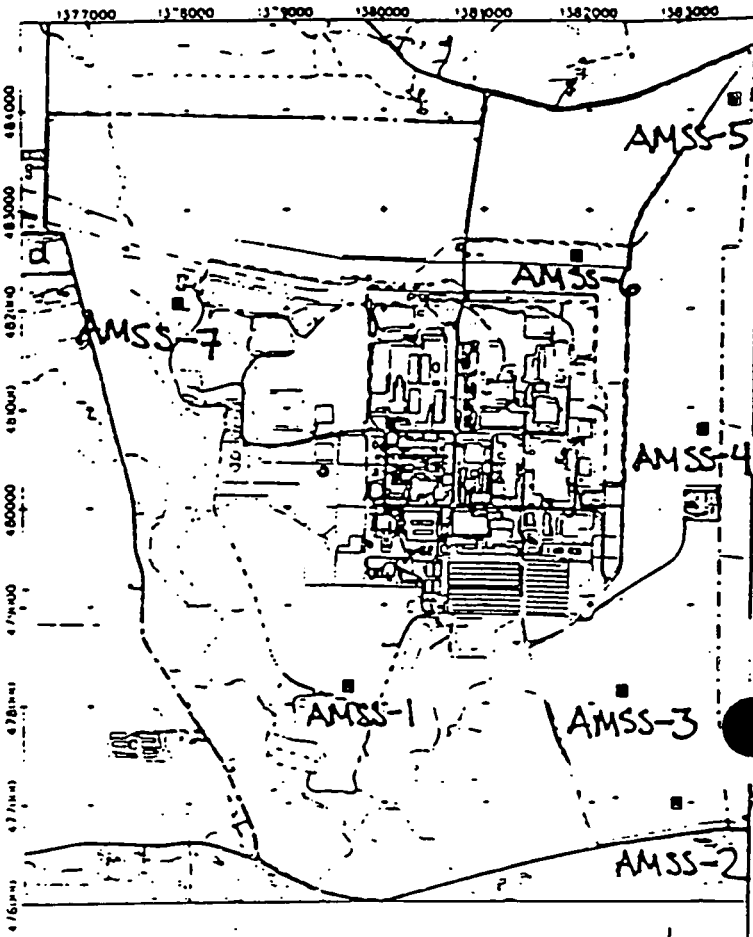
10 drive at AMSS-4 which is located 25 feet northeast of MW 2051 and collect 1 gal of the top cm of surface soil.

:0 arrive at AMSS-5 which is located 50 feet south of MW 2754 and collect 1 gallon of the top centimeter of surface soil.

:7 arrive at AMSS-6 which is located 30 feet northeast of lysimeters 11132/11133 and collect 1 gal of the top cm of surface soil.

arrive at AMSS-7 which is located 80 feet north of the railroad spur and collect 1 gallon of the top cm of surface soil.

perform sieve test for threshold friction velocity. on undried portion of each sample. see following sheets for results.



CAS 24 May 94

H-NU CALIBRATED BY
ON N/A
USING
LOT #

one gallon provides enough volume for the mass required.

SITORS ON SITE:	CHANGES FROM PLANS AND SPECIFICATIONS, AND OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS.
none	none
ATHER CONDITIONS: 7:30 a.m. 70°F, clear, 69% rel. humidity	IMPORTANT TELEPHONE CALLS: none

PERSONNEL ON SITE: M. Cheney, C. Sampson

PERVISOR: DATE:

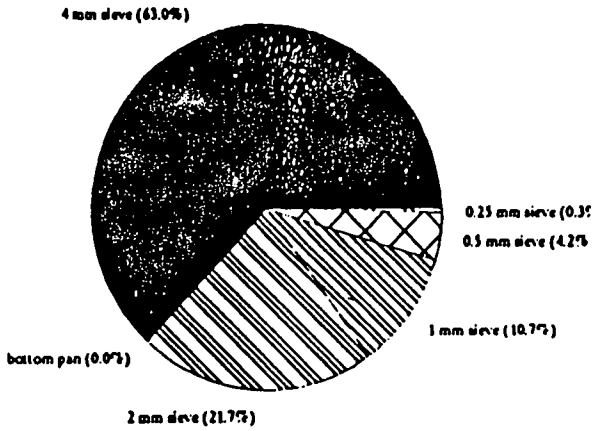
000256

AMSS–1: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

16 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	186.2682	–
	4	150.5971	–
	4	174.5217	–
	4	162.4734	–
	4	130.2578	–
	4	157.4585	–
TOTAL (4 mm)		961.5767	63.0324
	2	158.2942	–
	2	172.7507	–
TOTAL (2 mm)		331.0449	21.7004
	1	163.6233	10.7257
	0.5	63.9924	4.1948
	0.25	4.7865	0.3138
	bottom pan	0.5033	0.0330
GRAND TOTAL		1525.5271	100.0000

AMSS–1 UNDRIED



000257

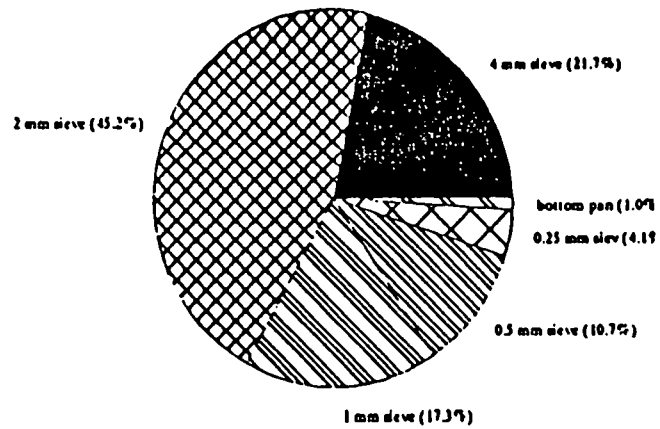
6349

AMSS–1: SECOND ROUND ANALYSIS (DRIED SAMPLE)

17 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	109.9244	–
	4	30.2724	–
TOTAL (4 mm)		140.1968	21.7071
	2	142.7920	–
	2	149.3075	–
TOTAL (2 mm)		292.0995	45.2267
	1	111.4850	17.2616
	0.5	69.4273	10.7497
	0.25	26.3671	4.0825
	bottom pan	6.2803	0.9724
GRAND TOTAL		645.8560	100.0000

AMSS–1 DRIED



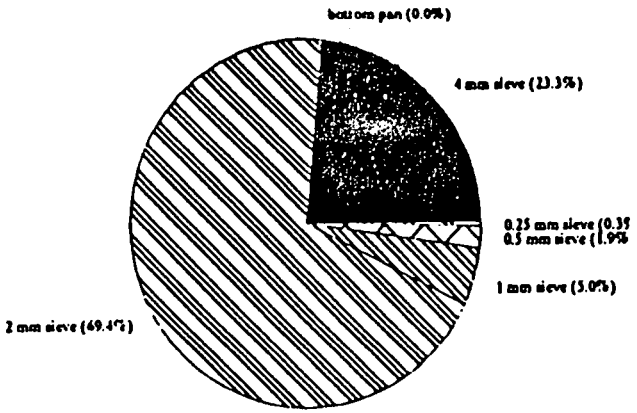
000258

AMSS–2: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	170.1887	–
	4	120.9280	–
TOTAL (4 mm)		291.1167	23.2821
	2	176.5287	–
	2	148.7673	–
	2	152.7739	–
	2	133.1967	–
	2	154.0193	–
	2	102.4138	–
TOTAL (2 mm)		867.6997	69.3945
	1	62.7759	5.0205
	0.5	24.2857	1.9423
	0.25	3.8942	0.3114
	bottom pan	0.6145	0.0491
GRAND TOTAL		1250.3867	100.0000

AMSS–2 UNDRIED



Bottom Pan 0.04%

000259

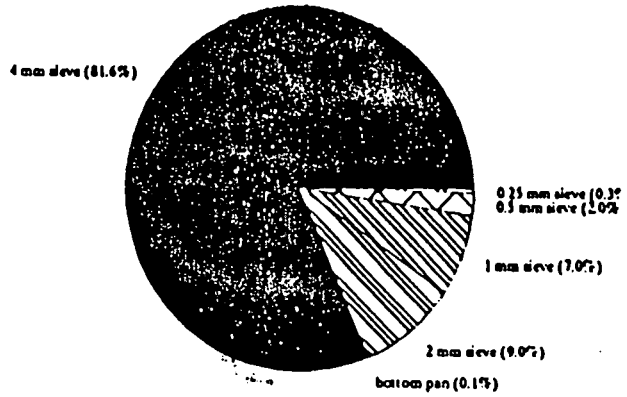
63469

AMSS–2: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	136.9347	–
	4	172.6359	–
	4	164.4926	–
	4	182.0699	–
	4	153.4438	–
	4	179.5860	–
TOTAL (4 mm)		989.1629	89.7168
TOTAL (2 mm)	2	109.3867	9.9213
	1	84.5820	7.6716
	0.5	24.2857	2.2027
	0.25	3.8942	0.3532
	bottom pan	0.6145	0.0557
GRAND TOTAL		1102.5393	100.0000

AMSS–2 DRIED



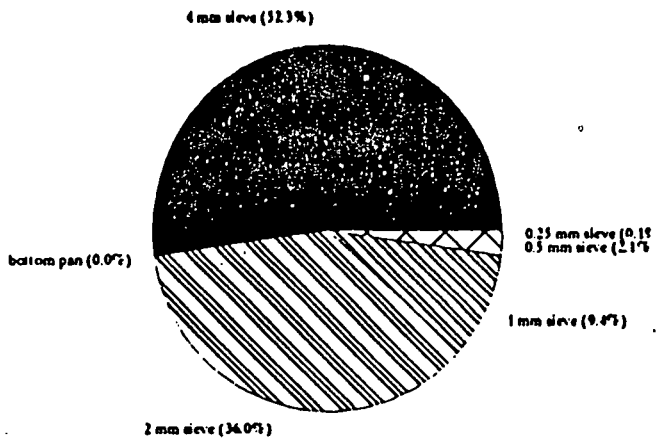
0062260

AMSS–3: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	230.4405	–
	4	292.0446	–
	4	90.651	–
TOTAL (4 mm)		613.1361	52.2689
	2	210.142	–
	2	212.5559	–
TOTAL (2 mm)	2	422.6979	36.0343
	1	110.4759	9.4179
	0.5	24.6021	2.0973
	0.25	1.5620	0.1332
	bottom pan	0.5689	0.0485
GRAND TOTAL		1173.0429	100.0000

AMSS–3 UNDRIED



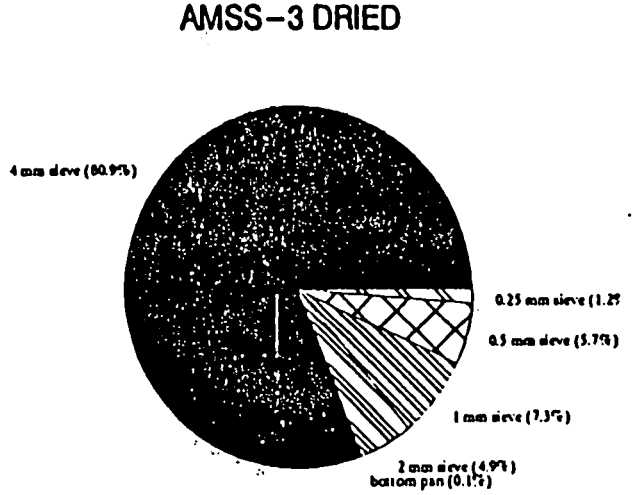
000264

63-46

AMSS–3: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	274.4335	–
	4	221.5245	–
	4	201.1976	–
	4	192.5464	–
	4	293.3461	–
	4	217.8029	–
TOTAL (4 mm)		1400.8510	80.8886
	2	84.0198	4.8515
	1	125.8425	7.2665
	0.5	99.1030	5.7225
	0.25	20.8473	1.2038
	bottom pan	1.1642	0.0672
GRAND TOTAL		1731.8278	100.0000



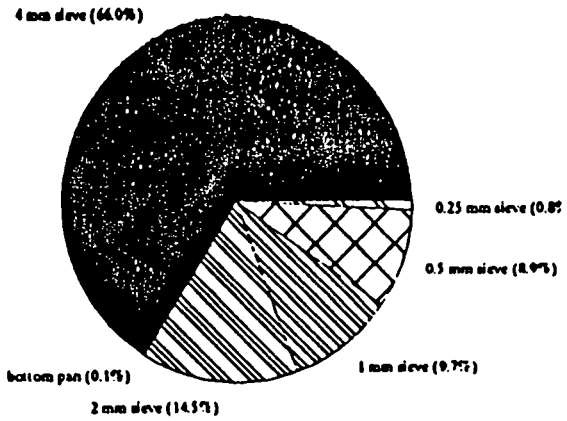
000262

AMSS–4: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	177.6342	–
	4	232.1742	–
	4	94.2951	–
TOTAL (4 mm)		504.1035	66.0249
	2	110.5028	14.4731
	1	74.2678	9.7272
	0.5	67.6466	8.8600
	0.25	6,0983	0.7987
	bottom pan	0.8856	0.1160
GRAND TOTAL		763.5046	100.0000

AMSS–4 UNDRIED



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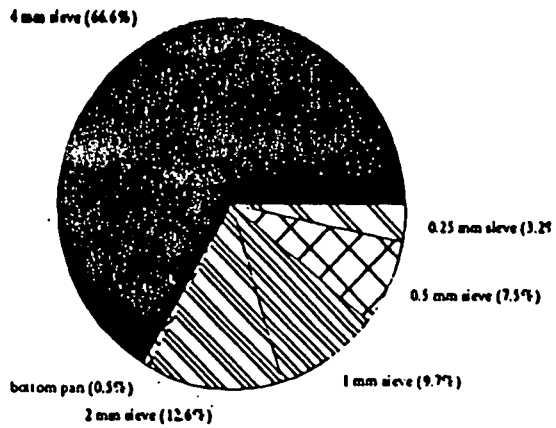
6349

AMSS–4: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	182.0931	–
	4	168.0479	–
	4	163.9286	–
	4	150.2297	–
	4	218.2032	–
	4	130.7362	–
TOTAL (4 mm)		1013.2387	66.5481
	2	191.3468	12.5674
	1	147.4421	9.6838
	0.5	114.1321	7.4960
	0.25	48.1184	3.1604
	bottom pan	8.2867	0.5443
GRAND TOTAL		1522.5648	100.0000

AMSS–4 DRIED



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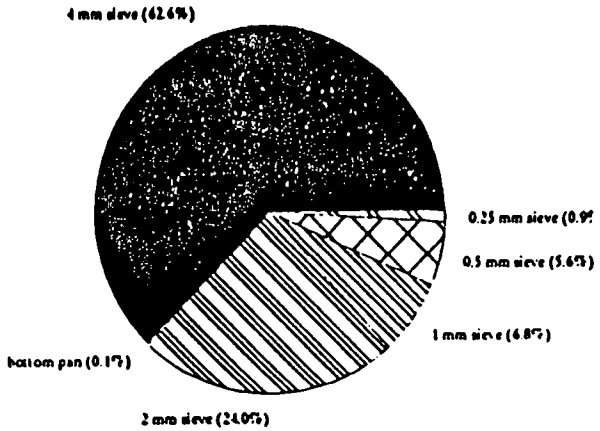
AMSS–5: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	143.255	–
	4	255.4269	–
	4	231.9034	–
TOTAL (4 mm)		630.5853	62.6198
	2	241.3999	23.9721
	1	68.0887	6.7615
	0.5	56.1226	5.5732
	0.25	9.3301	0.9265
	bottom pan	1.4790	0.1469
GRAND TOTAL		1007.0056	100.0000

AMSS–5 UNDRIED



000285

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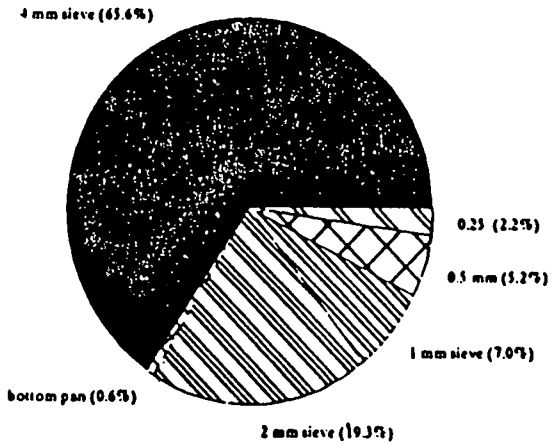
AMSS–5: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	187.4928	–
	4	187.1055	–
	4	150.4474	–
	4	253.9621	–
	4	149.2698	–
	4	81.6306	–
TOTAL (4 mm)		1009.9082	65.6314
	2	145.4633	–
	2	152.2052	–
	2	297.6685	19.3447
	1	107.9226	7.0136
	0.5	79.8055	5.1864
	0.25	33.6869	2.1892
	bottom pan	9.7648	0.6346
GRAND TOTAL		1538.7565	100.0000

AMSS–5 DRIED



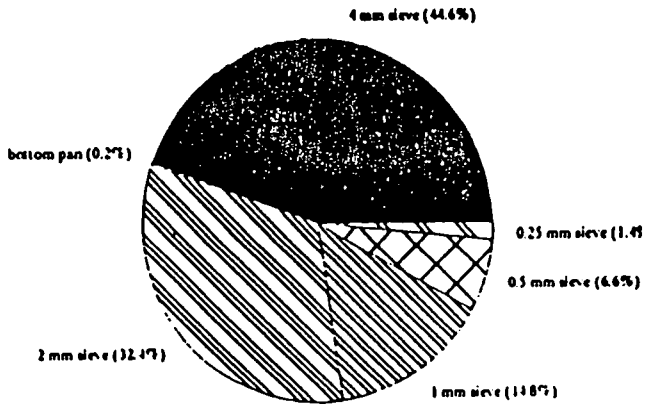
992000

AMSS–6: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	286.6849	–
	4	233.8654	–
TOTAL (4 mm)		520.5503	44.6282
	2	196.5609	–
	2	181.1500	–
TOTAL (2 mm)	2	377.7109	32.3822
	1	172.8813	14.8216
	0.5	76.6644	6.5726
	0.25	16.6024	1.4234
	bottom pan	2.0067	0.1720
GRAND TOTAL		1166.416	100.0000

AMSS–6 UNDRIED



492000

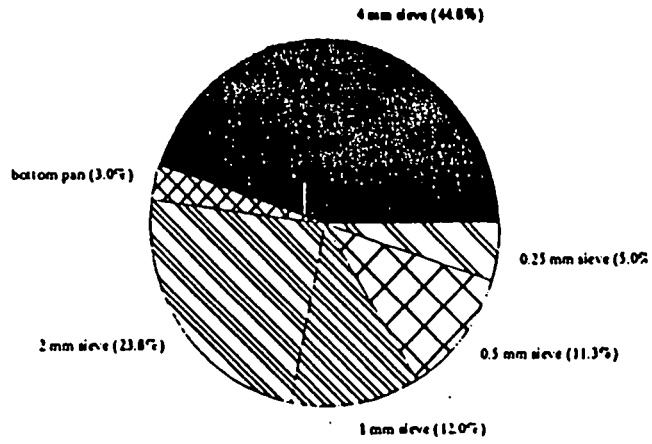
6349

AMSS–6: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	229.9556	–
	4	252.4993	–
	4	212.8934	–
	4	174.4352	–
TOTAL (4 mm)		869.7835	44.8151
	2	208.4835	–
	2	253.9685	–
TOTAL (2 mm)	2	462.4520	23.8276
	1	232.5279	11.9809
	0.5	218.8567	11.2765
	0.25	98.0382	5.0514
	bottom pan	59.1696	3.0487
GRAND TOTAL		1940.8279	100.0000

AMSS–6 DRIED



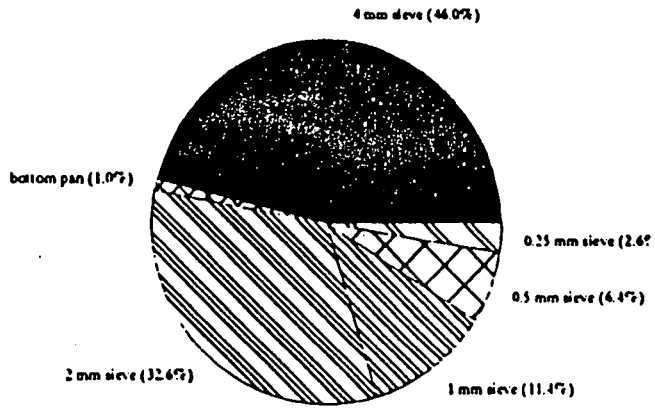
000268

AMSS–7: FIRST ROUND ANALYSIS (UNDRIED SAMPLE)

24 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	257.4664	–
	4	236.422	–
	4	98.0572	–
TOTAL (4 mm)		591.9456	46.0001
	2	224.7165	–
	2	194.5663	–
TOTAL (2 mm)	2	419.2828	32.5825
	1	146.9254	11.4176
	0.5	82.1776	6.3860
	0.25	33.3590	2.5923
	bottom pan	13.1439	1.0214
GRAND TOTAL		1286.8343	100.0000

AMSS–7 UNDRIED



000269

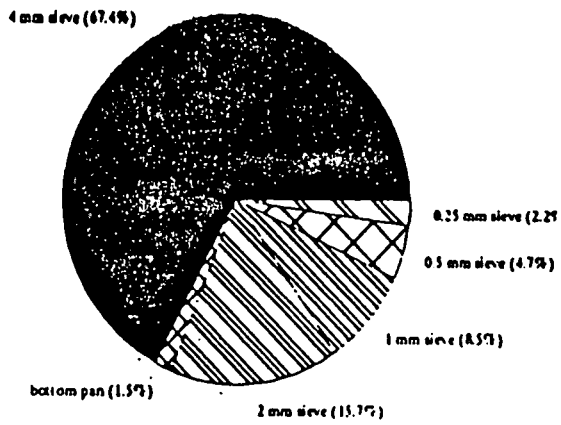
6349

AMSS–7: SECOND ROUND ANALYSIS (DRIED SAMPLE)

25 May 1994

	Sieve Size (mm)	Soil Retained (g)	Percent Composition (%)
	4	204.1471	–
	4	245.4404	–
	4	247.7468	–
	4	295.9912	–
	4	281.8278	–
	4	75.9872	–
TOTAL (4 mm)		1351.1405	67.3694
	2	226.3793	–
	2	88.0032	–
TOTAL (2 mm)	2	314.3825	15.6755
	1	171.1355	8.5330
	0.5	94.7386	4.7238
	0.25	43.6029	2.1741
	bottom pan	30.5702	1.5243
GRAND TOTAL		2005.5702	100.0000

AMSS–7 DRIED



002270

ATTACHMENT H.III

QUANTIFICATION OF CONTAMINANT EXPOSURE AND INTAKE

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H.III.1.3	Fish Products	H.III-5
H.III.1.4	Results of Food Product Fate Modeling	
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000273

H.III QUANTIFICATION OF CONTAMINANT EXPOSURE AND INTAKE

This attachment presents a detailed discussion of the methodologies used in the quantification of receptors exposure to and intake of COCs via food pathways. Section H.III.1 describes the equations used for the determination of contaminants in food products raised on or adjacent to the FEMP. Section H.III.2 describes the quantification methodologies used for evaluating potential carcinogenic and non-carcinogenic health effects. The media-contaminant specific equations and respective parameters are presented in Section H.III.3 and H.III.4.

H.III.1 FOOD PRODUCT FATE MODELING

This section describes the equations used to estimate exposure to chemicals and radionuclides from ingestion of contaminated food products.

H.III.1.1 Ingestion of Vegetables

The equations used to estimate exposure to chemicals and radionuclides via ingestion of vegetables irrigated with contaminated water are from the NRC (NRC 1977) and the EPA (EPA 1990d). This process involves estimating the concentration of the contaminant on and in the plant as a result of foliar deposition and root uptake. The model used to estimate the concentration in and on vegetation irrigated with contaminated water is (NRC 1977):

$$C_{ivw} = d_w \left[\frac{r_w (1 - e^{-\lambda_{Ei} t_e})}{Y \lambda_{Ei}} + \frac{f_w B_{iv} (1 - e^{-\lambda_{di} t_{bw}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t_h} \qquad \text{(H.III-1)}$$

For vegetation exposed to atmospheric fallout of dust, the equation becomes (NRC 1977):

$$C_{ivd} = d_d \left[\frac{r_d (1 - e^{-\lambda_{Ei} t_e})}{Y \lambda_{Ei}} + \frac{f_d B_{iv} (1 - e^{-\lambda_{di} t_{bd}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t_h} \qquad \text{(H.III-2)}$$

where

λ_{Ei} = effective depletion constant of ith contaminant on the plant surface (hr^{-1}),
λ_{di} = effective depletion constant from root zone of soil (hr^{-1}),
λ_{ri} = radioactive or chemical decay constant of ith contaminant (hr^{-1}), (Howard 1991)
B_{iv} = dry soil to wet plant (vegetables, forage, and fruit) transfer coefficient of ith contaminant,
C_{ivd} = concentration of ith contaminant in plants as a result of deposition of contaminated dust on plants (pCi/kg or mg/kg),
C_{ivw} = concentration of ith contaminant in plants as a result of irrigating plants with contaminated water (pCi/kg or mg/kg),
d_d = dust deposition rate (pCi/m^2-hr or mg/m^2-hr),
d_w = irrigation deposition rate (pCi/m^2-hr or mg/m^2-hr),
f_w = fraction of year plant is irrigated (unitless),

f_d = fraction of year plant is downwind (unitless),
ρ = effective dry surface density of the soil (kg/m^2),
r_d = fraction of deposited dust retained on plant surface (unitless),
r_w = fraction of water borne material retained on plant surface (unitless),
t_{bd} = period soil is exposed to airborne emissions (hr),
t_{bw} = period soil is exposed to contaminated water (hr),
t_e = growing season (hr),
t_h = duration of period between harvest and consumption (hr), and
Y = agricultural yield (kg/m^2),

and

$$\lambda_{di} = \lambda_{Ri} + \lambda_{Li} \qquad \text{(H.III-3)}$$

$$\lambda_{Li} = \frac{V_w}{Z\theta\left[1 + \sigma\,\frac{K_d}{\theta}\right]} \qquad \text{(H.III-4)}$$

$$d_w = (C_{iw})(I) \qquad \text{(H.III-5)}$$

$$d_d = (C_{id})(v_d) \qquad \text{(H.III-6)}$$

where

C_{iw} = concentration of ith contaminant in irrigation water (pCi/L or mg/L),
I = irrigation rate (L/m^2/hr),
C_{id} = concentration of ith contaminant in dust (pCi/g or mg/g),
K_d = water to soil partitioning coefficient of constituent (cm^3/g),
λ_{Li} = leachate removal constant (hr^{-1})
θ = moisture fraction of soil in root zone (unitless),
σ = density of soil in root zone (g/cm^3),
v_d = deposition velocity for dust (g/m^2/hr), Attachment H.II,
V_w = percolation rate (cm/hr), and
Z = depth of root zone (cm).

In addition to exposure to contaminated irrigation water and dust, vegetables and livestock feed may be contaminated by root uptake from contaminated soil. The contribution by this pathway is estimated by the irrigation model; however, this pathway is also considered for areas that are not irrigated with contaminated water but that exhibit surface soil contamination from historical deposition on the soil by other means. The following equation (NRC 1977) was used to estimate the contaminant concentration in the plant from root uptake of contaminants in the soil.

$$C_{ivs} = (C_s)(B_{iv})(e^{-\lambda_{ri} t_h}) \quad \text{(H.III-7)}$$

where

C_{ivs} = concentration of ith contaminant in plants as a result of root uptake from contaminated soil (pCi/kg or mg/kg), and
C_s = concentration of ith contaminant in dry soil at harvest time (pCi/kg or mg/kg).

The total concentration of contaminants in vegetables (C_{iv}) is estimated using the following equation:

$$C_{iv} = C_{ivw} + C_{ivd} + C_{ivs} \quad \text{(H.III-8)}$$

Equations of the same form were used to estimate the contaminant concentration in livestock feed, substituting concentration factors for livestock feed in place of those for vegetables ingested by man.

A summary of parameters used in the vegetable and forage uptake models is presented in Table H.III-1. Radioactive or chemical decay constants are presented in Table H.III-2. Transfer coefficients of contaminants from dry soil to wet plant material are presented in Table H.III-3. Source concentrations for food product fate modeling are presented in Table H.III-4.

H.III.1.2 Ingestion of Meat and Dairy Products

Prior to the determination of intake following ingestion of animal products by humans, the concentration of chemicals and radionuclides in animal products must be estimated. The concentration of a contaminant in animal products, such as beef or milk, was estimated using the following equation (NRC 1977):

$$C_{iA} = F_{iA}[(C_{if})(Q_f) + (C_{iAw})(Q_{Aw})]\, e^{-\lambda_{ri} t_{iA}} \quad \text{(H.III-9)}$$

where

C_{iA} = concentration of ith contaminant in the animal product (pCi/L for milk, pCi/kg for beef or mg/L for milk, mg/kg for beef),
F_{iA} = element (stable) transfer coefficient that relates the daily intake by an animal to the concentration of ith contaminant in an edible portion of the animal product (day/L for milk, day/kg for beef),
C_{if} = concentration of ith contaminant in forage (pCi/kg or mg/kg),
Q_f = consumption rate of contaminated forage by an animal (kg/day),
C_{iAw} = concentration of ith contaminant in livestock water (pCi/L or mg/L),
Q_{Aw} = consumption rate of contaminated water by an animal (L/day),
λ_{ri} = decay constant of ith contaminant (hr^{-1}), and
t_{iA} = delay between harvest of animal product (milk or meat) and consumption (hr).

Transfer coefficients of contaminants to milk or beef (F_{iA}) are presented in Table H.III-3. Contaminant concentrations in forage are presented in Table H.III-5.

In addition to intake from irrigated forage and water, cows may receive a significant intake from soil ingestion if the soil is also a source of contamination (Zach and Mayoh 1984). The following equation was used to estimate the concentration in the animal product from soil ingestion (EPA 1990d):

$$C_{iA} = F_{iA}[(C_s)(Q_s)]e^{(-\lambda_{di}t_A)} \qquad \text{(H.III-10)}$$

where

C_s = concentration of contaminant in soil (pCi/kg or mg/kg), and
Q_s = consumption rate of soil by livestock (kg/day).

Animal Consumption Rates

The following parameters were used to quantify the intake of contaminants in food and water by beef and milk cattle at or near the FEMP:

Animal	Q_f Feed or Forage[a] (kg wet weight/day)	Q_{Aw} Water[a] (L/day)	Q_s Soil[b] (kg/day)
Milk cow	50	60	0.5
Beef cattle	50	50	0.5

[a] NCR 1977
[b] Zach and Mayoh (1984)

Radionuclide and Nonradioactive Transfer Coefficients

Transfer coefficients for radionuclides and nonradioactive metals were taken from Baes et al. (1984), Till and Meyer (1983) and EPA (1989d). The radiological properties of atoms do not effect their elemental transfer in the environment. The soil-to-plant transfer coefficient for edible plants ingested by humans and forage ingested by cattle used in intake models, in the absence of site-specific information, are listed in Table H.III-3. These factors are the ratios of the dry-weight concentration of an element in the reproductive or vegetative portions of the plant to the dry-weight concentration of the element in soil. Edible portions of the plant include grain kernels, fruits, and tubers. These portions are most representative of the plant foods ingested by humans. The list of elements is not all inclusive. The cited references were used to obtain values for additional constituents of concern in individual risk assessments as needed.

Transfer coefficients for organic chemicals were taken from Travis and Arms (1988). If a transfer coefficient was not readily available, the following regression equations based on the relationship between transfer and the octanol-water partition coefficient (K_{ow}) were used to estimate transfer coefficients (Travis and Arms 1988):

$B_{iv(2)}$ (vegetables)	$\log B_{iv}$	$= 1.588 - 0.578 \log K_{ow}$
F_{iA} (milk)	$\log F_{iA}$	$= -8.10 + \log K_{ow}$
F_{iA} (beef)	$\log F_{iA}$	$= -7.6 + \log K_{ow}$

Chemical-specific K_{ow} values are available from several sources. The major source used for K_{ow} values was Hansch and Leo (1979).

H.III.1.3 Fish Products

The equation used to estimate contaminant concentrations in fish products originating from the Great Miami River is (NRC 1977):

$$C_{io} = (C_{sw})(f_n) \qquad \text{(H.III-11)}$$

where

C_{io} = concentration in fish (mg/kg, pCi/kg),
C_{sw} = concentration of contaminant in surface water (mg/L, pCi/L)
f_n = Bioconcentration factor for fish (L/kg)

Table H.III-3 presents the checmical-specific bioconcentration factors used in this CRARE. Table H.III-4 summarizes the chemical-specific surface water concentrations.

H.III.1.4 Results of Food Product Fate Modeling

Table H.III-6 presents a summary of modeling results for the contaminant concentrations in vegetables, meat, dairy, and fish products under the adopted site-wide remedy. These values have been incorporated into Section H.IV.

TABLE H.III-1

SUMMARY OF PARAMETERS FOR VEGETABLE/FORAGE UPTAKE MODELS

Parameter[a]	Value	Units	Reference
Typical Dust Settling Velocity (1/d)	6.48	m/h	NRC 1977
Irrigation Rate (I)	0.081	$L/m^2/hr$	USDA 1970
Percolation Rate (Vw)	1.28×10^{-3}	cm/h	DOE 1994a
Depth to Root Zone (Z)	15	cm	DOE 1994a
Density of Soil (σ)	1.5	g/cm^3	DOE 1994a
Moisture Fraction in Root Zone (θ)	0.17	unitless	DOE 1994a
Fraction of Deposited Dust Retained on Crops (r_d)	0.25	unitless	NRC 1977
Fraction of Water Borne Material Retained on Crops (r_w)	0.20	unitless	NRC 1977
Effective Depletion Constant of Contaminant on Plant Surface (λ_{Ei})	0.0021	hr^{-1}	NRC 1977
Growing Season for Vegetables and Fruit Crops (t_{ec})	1440	hr	NRC 1977
Growing Season for Forage (t_{eg})	720	hr	NRC 1977
Agricultural Yield of Vegetables and Fruit Crop (Y)	1.5	kg/m^2	USDA 1979
Agricultural Yield of Forage (Y)	0.8	kg/m^2	USDA 1979
Fraction of Year Plants are Downwind (f_d)	0.5[b]	unitless	—
Fraction of Year Plans are Irrigated (f_w)	1.0[c]	unitless	NRC 1977
Period Soil is Exposed to Contaminated Water (t_{bw})	8,760,000	hr	Assumed
Period Soil is Exposed to Airborne Emissions (t_{bd})	8,760,000	hr	Assumed
Effective Dry Surface Density of the Soil (ρ)	150[d]	kg/m^3	USDA 1982
Delay between Harvest and Consumption of Vegetables (t_{hv})	24	hr	NRC 1977
Delay between Harvest and Consumption of Vegetables and Fruit (t_{hc})	720	hr	Assumed
Delay between Harvest and Consumption of Forage (t_{hg})	0	hr	NRC 1977
Delay between Milking and Consumption (t_{iA})	48	hr	NRC 1977
Delay between Slaughter and Consumption	480	hr	NRC 1977

[a] See the uncertainty analysis (Section H.5.0) for more information on these parameters.
[b] CRARE modeled RME location.
[c] The fraction of time plants are irrigated is implicitly included in the irrigation rate. To avoid using this parameter twice in Equation 7-9, f_d has been set to 1.0.
[d] Corresponds to a density of 1.5 g/cm^3 and a depth of 10 cm. Moist bulk densities of surface soil range from 1.4 to 1.55 g/cm^3 at the FEMP (USDA 1982).

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TABLE H.III-2

CHEMICAL AND RADIOACTIVE COC DECAY CONSTANTS

Chemical	Decay Constant (λ_{ri}) (hr^{-1})	Radionuclide	Decay Constant (λ_{ri}) (hr^{-1})
Antimony	1.00×10^{-14}	Ra-226 + 8d	4.95×10^{-8}
Aroclor-1254	1.00×10^{-14}	Rn-222	NA
Aroclor-1260	1.00×10^{-14}	Sr-90 + Id	2.77×10^{-6a}
Arsenic	1.00×10^{-14}	Tc-99	3.71×10^{-10a}
Benzo(a)pyrene	1.00×10^{-14}	Th-230	1.03×10^{-9}
Beryllium	1.00×10^{-14}	Th-232 + 10d	5.63×10^{-15}
Cadmium	1.00×10^{-14}	U-235/236	1.12×10^{-13}
1, 2-dichloroethane	1.00×10^{-14}	U238 + 2d	1.77×10^{-14}
Magnesium	1.00×10^{-14}		
Manganese	1.00×10^{-14}		
Mercury	1.00×10^{-14}		
Silver	1.00×10^{-14}		
2,3,7,8-TCDD	1.00×10^{-14}		
Trichloroethene	1.00×10^{-14}		
Uranium-total	1.00×10^{-14}		

SOURCE: SWCR (DOE 1993) except as noted.
[a] From Grove Engineering (1991)
NA = Not applicable

TABLE H.III-3

K_d AND TRANSFER COEFFICIENTS

COC	K_d(cm³/g)	Beef $_{Fia}$(d/kg)	Source	Milk $_{Fia}$(d/L)	Source	Vegetable $B_{(IV2)}$	Source	Forage $B_{(IV1)}$	Source	Fish f_n (L/g)	Source
Chemicals											
Antimony	4.50×10^{1}	1.00×10^{-3}	a	6.00×10^{-5}	c	1.28×10^{-2}	d	3.00×10^{-2}	a	1.00×10^{0}	d
Aroclor-1254	8.86×10^{3}	2.69×10^{-2}	a	8.50×10^{-3}	c	3.04×10^{-3}	d	7.10×10^{-3}	a	2.25×10^{4}	d
Aroclor-1260	1.07×10^{4}	3.02×10^{-1}	a	1.11×10^{-1}	c	4.71×10^{-3}	d	1.10×10^{-2}	a	1.59×10^{5}	d
Arsenic	2.00×10^{2}	2.00×10^{-3}	a	6.00×10^{-5}	d	1.71×10^{-2}	d	4.00×10^{-2}	a	4.40×10^{1}	d
Benzo(a)pyrene	1.83×10^{4}	3.16×10^{-2}	a	1.00×10^{-2}	d	4.94×10^{-3}	d	1.15×10^{-2}	a	2.55×10^{4}	d
Beryllium	2.50×10^{2}	1.00×10^{-3}	a	9.00×10^{-7}	d	4.28×10^{-3}	d	1.00×10^{-2}	a	1.90×10^{1}	d
Cadmium	1.2×10^{1}	5.50×10^{-4}	a	1.00×10^{-3}	d	2.35×10^{-1}	d	5.50×10^{-1}	a	8.10×10^{1}	d
1,2-dichloroethane	ND	1.26×10^{-2}	a	3.98×10^{-3}	d	7.70×10^{-3}	d	1.80×10^{-2}	a	1.26×10^{4}	d
Magnesium	3.80×10^{1}	3.00×10^{-4}	a	2.50×10^{-4}	d	1.93×10^{-2}	d	4.50×10^{-2}	a	4.90×10^{1}	d
Manganese	5.0×10^{1}	4.00×10^{-4}	a	3.50×10^{-4}	d	1.07×10^{-1}	d	2.50×10^{-1}	a	NA	
Mercury	1.00×10^{1}	2.50×10^{-1}	a	4.50×10^{-4}	d	3.85×10^{-1}	d	9.00×10^{-1}	a	5.50×10^{3}	d
Silver	9.00×10^{1}	3.00×10^{-3}	d	2.00×10^{-2}	d	1.71×10^{-1}	d	4.00×10^{-1}	d	3.10×10^{3}	d
2,3,7,8-TCDD	ND	1.58×10^{-1}		5.01×10^{-2}		1.95×10^{-3}		4.55×10^{-3}		8.67×10^{4}	d
Trichloroethene	3.20×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-4}	d	8.50×10^{-4}	a	3.00×10^{1}	d
Uranium-total	ND	2.00×10^{-4}	a	6.00×10^{-4}	d	3.64×10^{-3}	d	8.50×10^{-3}	a	2.00×10^{0}	d
Radionuclides											
Ra-226+8d	1.06×10^{2}	2.50×10^{-4}	a	4.50×10^{-4}	d	6.42×10^{-3}	d	1.50×10^{-2}	a	5.00×10^{1}	d
Rn-222	NA	NA		NA		NA		NA		NA	
Sr-90+1d	2.50×10^{0}	3.00×10^{-4}	a	1.50×10^{-3}	d	1.07×10^{0}	d	2.50×10^{0}	a	3.00×10^{1}	d
Tc-99	7.00×10^{-2}	8.50×10^{-3}	a	1.00×10^{-2}	d	4.07×10^{0}	d	9.50×10^{0}	a	1.50×10^{1}	d
Th-230	3.20×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-4}	d	8.50×10^{-4}	d	3.00×10^{1}	d
Th-232+10d	3.20×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-4}	d	8.50×10^{-4}	d	3.00×10^{1}	d

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TABLE H.III-3
(Continued)

COC	K_d(cm³/g)	Beef $_{Fia}$(d/kg)	Source	Milk $_{Fia}$(d/L)	Source	Vegetable $B_{(IV2)}$	Source	Forage $B_{(IV1)}$	Source	Fish f_n (L/g)	Source
Radionuclides (Continued)											
U-235/236	1.48×10^{0}	2.00×10^{-4}	a	6.00×10^{-4}	d	3.64×10^{-3}	d	8.50×10^{-3}	d	2.00×10^{0}	d
U-238+2d	1.48×10^{0}	2.00×10^{-4}	a	6.00×10^{-4}	d	3.64×10^{-3}	d	8.50×10^{-3}	d	2.00×10^{0}	d

[a] SWCR (DOE 1993a)

[b] Log of bioconcentration factor in beef (Log B_b) calculated from geometric mean regression model: Log B_b = -7.6 + Log K_{ow} (RAWPA; DOE 1992a)

[c] Log of Biotransfer factor in milk (Log B_m) calculated from geometric mean regression model: Log B_m = -8.10 + Log K_{ow} (RAWPA; DOE 1992a)

[d] Operable Unit 2 RI Report (DOE 1994a)

[e] Log of bioconcentration factor in vegetation (Log B_v) calculated from geometric mean regression model: Log B_v = 1.588 - 0.578 Log K_{ow} (RAWPA; DOE 1992a)

NA - Not Available

ND - Not Detected

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TABLE H.III-4

SOURCE CONCENTRATIONS FOR FOOD PRODUCTS FATE MODELING

	C_{id} (mg/m³, pCi/m³)		C_{iw} (mg/L, pCi/L)		C_s (mg/kg, pCi/kg)		C_{sw} (mg/L, pCi/L)
COC	Off-Property	On-Property	Off-Property	On-Property	On-Property	Off-Property	Great Miami River
Inorganics							
Antimony	ND	ND	ND	ND	3.23×10^{-1}	ND	8.48×10^{-6}
Arsenic	7.83×10^{-7}	1.80×10^{-10}	ND	ND	1.92×10^{-1}	ND	ND
Beryllium	1.22×10^{-11}	2.80×10^{-11}	ND	ND	6.18×10^{-2}	ND	1.87×10^{-6}
Cadmium	1.39×10^{-11}	3.20×10^{-11}	ND	ND	7.59×10^{-2}	ND	ND
Magnesium	7.88×10^{-7}	1.54×10^{-6}	ND	ND	2.82×10^{3}	2.63×10^{2}	ND
Manganese	ND	ND	ND	1.42×10^{-2}	ND	ND	ND
Mercury	ND	ND	ND	ND	ND	ND	8.18×10^{-5}
Silver	ND	ND	ND	ND	ND	ND	ND
Uranium-total	9.50×10^{-9}	1.78×10^{-8}	5.20×10^{-3}	8.61×10^{-3}	8.30×10^{0}	3.93×10^{0}	ND
Organics							
Aroclor-1254	2.37×10^{-11}	3.16×10^{-11}	ND	ND	2.46×10^{-2}	2.20×10^{-2}	ND
Aroclor-1260	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND
2,3,7,8-TCDD	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	1.87×10^{-11}	2.22×10^{-11}	ND	ND	2.0×10^{-2}	2.00×10^{-2}	7.08×10^{-9}
Trichloroethene	1.29×10^{-12}	8.84×10^{-13}	ND	ND	7.55×10^{-4}	2.00×10^{-3}	ND
Radionuclides							
Ra_{226}+8d	1.23×10^{-7}	2.84×10^{-7}	ND	3.28×10^{-10}	3.84×10^{2}	ND	7.37×10^{-5}
Rn_{222}	ND	ND	ND	ND	ND	ND	ND
Sr_{90}+1d	4.86×10^{-8}	9.60×10^{-8}	5.36×10^{-6}	2.88×10^{-2}	1.19×10^{2}	1.50×10^{1}	7.43×10^{-2}
Tc_{99}	6.68×10^{-7}	2.76×10^{-7}	4.18×10^{-1}	1.68×10^{1}	2.50×10^{2}	2.50×10^{2}	2.23×10^{0}
Th_{230}	4.86×10^{-7}	8.42×10^{-7}	ND	ND	6.45×10^{2}	2.65×10^{2}	1.23×10^{-3}
Th_{232}+10d	3.48×10^{-9}	8.00×10^{-9}	ND	ND	3.17×10^{1}	ND	8.44×10^{-6}
$U_{235/236}$	9.90×10^{-9}	ND	8.29×10^{-2}	1.33×10^{-1}	ND	2.19×10^{1}	6.61×10^{-4}
U_{238}+2d	3.17×10^{-6}	5.92×10^{-6}	1.87×10^{0}	3.01×10^{0}	2.77×10^{3}	1.32×10^{3}	1.49×10^{-2}

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TABLE H.III-5

COC CONCENTRATIONS IN FORAGE

COC	C_{if} (mg/kg, pCi/kg) Off-Property	On-Property
Antimony	2.38×10^{-5}	6.46×10^{-2}
Arsenic	2.43×10^{-5}	7.68×10^{-3}
Beryllium	2.07×10^{-6}	6.18×10^{-4}
Cadmium	6.57×10^{-5}	4.18×10^{-2}
Magnesium	3.29×10^{-2}	2.82×10^{3}
Manganese	1.57×10^{-2}	6.71×10^{-5}
Mercury	7.25×10^{-7}	ND
Silver	8.50×10^{-5}	ND
Uranium-total	9.60×10^{-6}	7.06×10^{-2}
Organics		
Aroclor-1254	ND	3.12×10^{-4}
Aroclor-1260	ND	ND
Benzo(a)pyrene	6.03×10^{-9}	2.31×10^{-4}
1,2-Dichloroethane	ND	ND
2,3,7,8-TCDD	ND	ND
Trichloroethene	3.56×10^{-9}	1.20×10^{-3}
Radionuclides		
Ra_{226}+8d	ND	5.76×10^{0}
Rn_{222}	ND	ND
Sr_{90}+1d	7.17×10^{-3}	2.98×10^{2}
Tc_{99}	8.82×10^{-4}	2.38×10^{3}
Th_{230}	3.04×10^{-4}	5.50×10^{-1}
Th_{232}+10d	ND	2.70×10^{-2}
$U_{235/236}$	6.69×10^{-5}	ND
U_{238}+2d	2.17×10^{-3}	2.36×10^{1}

TABLE H.III-6

MODELED FOOD PRODUCT COC CONCENTRATIONS: ON-SITE RESIDENT FOOD RECEPTORS

COC	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/L)	Vegetable Concentration (mg/kg)
Antimony	3.39×10^{-6}	3.39×10^{-4}	6.46×10^{-2}
Arsenic	9.60×10^{-7}	2.88×10^{-5}	7.68×10^{-3}
Beryllium	6.18×10^{-8}	5.56×10^{-8}	6.18×10^{-4}
Cadmium	1.17×10^{-6}	2.13×10^{-3}	4.18×10^{-2}
Magnesium	7.12×10^{-1}	5.70×10^{2}	2.82×10^{3}
Manganese	2.85×10^{-7}	2.99×10^{-4}	7.01×10^{-2}
Mercury	ND	ND	ND
Silver	ND	ND	ND
Uranium-total	1.62×10^{-6}	4.92×10^{-3}	1.13×10^{-1}
Organics			
Aroclor-1254	7.50×10^{-7}	2.37×10^{-4}	3.12×10^{-4}
Aroclor-1260	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
2,3,7,8-TCDD	ND	ND	ND
Benzo(a)pyrene	6.79×10^{-7}	2.15×10^{-4}	2.31×10^{-4}
Trichloroethene	3.77×10^{-10}	1.20×10^{-7}	1.20×10^{-3}
Radionuclides			
$Ra_{226}+8d$	1.20×10^{-4}	2.16×10^{-1}	5.76×10^{0}
Rn_{222}	ND	ND	ND
$Sr_{90}+1d$	4.47×10^{-3}	2.24×10^{1}	2.98×10^{2}
Tc_{99}	1.02×10^{0}	1.20×10^{3}	2.48×10^{3}
Th_{230}	2.10×10^{-6}	1.75×10^{-3}	5.49×10^{-1}
$Th_{232}+10d$	1.03×10^{-7}	8.60×10^{-5}	2.70×10^{-2}
$U_{235/236}$	1.33×10^{-6}	4.79×10^{-3}	6.51×10^{-1}
$U_{238}+2d$	5.43×10^{-4}	1.65×10^{0}	3.83×10^{1}

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TABLE H.III-7

MODELED FOOD PRODUCT COC CONCENTRATIONS: OFF-SITE RESIDENT FOOD RECEPTORS

COC	Meat Concentration (mg/kg, pCi/kg)	Dairy Product Concentration (mg/L, pCi/L)	Vegetable Concentration (mg/kg, pCi/kg)
Antimony	ND	ND	ND
Arsenic	2.77×10^{-11}	8.31×10^{-10}	2.56×10^{-7}
Beryllium	1.41×10^{-12}	1.27×10^{-12}	2.51×10^{-8}
Cadmium	2.57×10^{-11}	4.67×10^{-8}	9.31×10^{-7}
Magnesium	6.64×10^{-2}	5.31×10^{1}	2.63×10^{2}
Manganese	ND	ND	ND
Mercury	ND	ND	ND
Silver	ND	ND	ND
Uranium-total	7.79×10^{-7}	2.37×10^{-3}	5.88×10^{-2}
Organics			
Aroclor-1254	6.71×10^{-7}	2.12×10^{-4}	2.79×10^{-4}
Aroclor-1260	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
2,3,7,8-TCDD	ND	ND	ND
Benzo(a)pyrene	6.79×10^{-7}	2.15×10^{-4}	2.31×10^{-4}
Trichloroethene	1.00×10^{-9}	3.19×10^{-7}	3.17×10^{-3}
Radionuclides			
$Ra_{226}+8d$	3.76×10^{-9}	6.78×10^{-6}	2.69×10^{-4}
Rn_{222}	ND	ND	ND
$Sr_{90}+1d$	5.64×10^{-4}	2.82×10^{0}	3.75×10^{1}
Tc_{99}	1.01×10^{0}	1.19×10^{3}	2.38×10^{3}
Th_{230}	8.63×10^{-7}	7.19×10^{-4}	2.26×10^{-1}
$Th_{232}+10d$	9.45×10^{-13}	7.88×10^{-10}	2.24×10^{-6}
$U_{235/236}$	4.88×10^{-6}	1.51×10^{-2}	5.92×10^{-1}
$U_{238}+2d$	2.63×10^{-4}	8.00×10^{-1}	2.04×10^{1}

TABLE H.III-8

MODELED FOOD PRODUCT COC CONCENTRATIONS: GREAT MIAMI RIVER USER

COC	Meat Concentration (mg/kg, pCi/kg)	Dairy Product Concentration (mg/L, pCi/L)	Vegetable Concentration (mg/kg, pCi/kg)
Antimony	4.24×10^{-10}	5.09×10^{-8}	4.15×10^{-5}
Arsenic	ND	ND	ND
Beryllium	9.35×10^{-11}	1.01×10^{-10}	9.15×10^{-6}
Cadmium	ND	ND	ND
Magnesium	ND	ND	ND
Manganese	ND	ND	ND
Mercury	1.02×10^{-6}	2.2×10^{-6}	4.03×10^{-4}
Silver	ND	ND	ND
Uranium-total	ND	ND	ND
Organics			
Aroclor-1254	ND	ND	ND
Aroclor-1260	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
2,3,7,8-TCDD	ND	ND	ND
Benzo(a)pyrene	1.11×10^{-11}	4.25×10^{-9}	3.46×10^{-8}
Trichloroethene	ND	ND	ND
Radionuclides			
Ra_{226} + 8d	9.21×10^{-10}	1.99×10^{-6}	3.61×10^{-4}
Rn_{222}	ND	ND	ND
Sr_{90} + 1d	1.11×10^{-6}	6.69×10^{-3}	3.67×10^{-1}
Tc_{99}	9.48×10^{-4}	1.34×10^{0}	1.14×10^{1}
Th_{230}	3.69×10^{-10}	3.69×10^{-7}	6.02×10^{-3}
Th_{232} + 10d	2.53×10^{-12}	2.53×10^{-9}	4.13×10^{-5}
$U_{235/236}$	6.61×10^{-9}	2.38×10^{-5}	3.23×10^{-3}
U_{238} + 2d	1.49×10^{-7}	5.36×10^{-4}	7.29×10^{-2}

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H.III.2 EXPOSURE QUANTIFICATION

This section defines the quantification methods used for evaluating cancer risks and the potential for adverse noncancer health effects on the impacted receptor. Results calculated for intake of COCs contributing to the calculated risks are presented in Attachment H.IV.

H.III.2.1 Definitions

Exposure is defined as the contact of an organism with a chemical or physical agent. When exposure occurs through inhalation or dermal ingestion, some of the contaminant is taken into the body. The amount of contaminant ingested or inhaled is referred to as the contaminant intake. The fraction of the contaminant absorbed into the body (across the membranes of the gastrointestinal or respiratory system, or through the skin after dermal contact) is referred to as the dose or the absorbed dose of contaminant. In the animal studies often used to develop toxicity values for risk assessment, the intake of contaminants is considered to be equivalent to the administered dose. Toxicity values (RfDs and cancer slope factors) are generally developed in terms of contaminant intake, rather than absorbed doses, particularly for ingestion and inhalation.

H.III.2.2 Quantification Methods

In evaluating cancer risks and the potential for adverse noncancer health effects, it was necessary to estimate contaminant intake for the exposed receptor. For both cancer and noncancer risk assessment, average long-term daily intakes were used to estimate risk. The chronic daily intake (CDI) for hazardous chemical contaminants were estimated as follows (EPA 1989a):

$$CDI = \frac{C \times CR \times EFD}{BW} \times \frac{1}{AT} \qquad \text{(H.III-12)}$$

where

CDI	=	chronic daily intake (mg/kg body weight/day),
C	=	chemical concentration in exposure medium (mg/L, mg/kg),
CR	=	contact rate with exposure medium (L/day, mg/day),
EFD	=	exposure frequency and duration (days/year, years),
BW	=	body weight (kg), and
AT	=	average time, e.g., the period over which exposure is averaged (days).

In the case of cancer risk assessment, the average lifetime daily intake was used to estimate the ILCR, thus AT equalled a full 70-year lifespan. For noncancer risk assessment, intake was evaluated over the period during which exposures occur, and AT equalled the duration of exposure. In the case of dermal exposures, time-weighted absorbed doses, rather than intakes, were calculated. Otherwise, time-weighted average doses were calculated in the same manner as the contaminant intakes described above.

Carcinogenic risks associated with radionuclides are estimated based upon the total activity (pCi) accumulated over a lifetime. The following general equation illustrates the method employed for lifetime intake quantification (DOE 1992a):

$$I = C \times CR \times EF \times ED \quad \text{(H.III-13)}$$

where

I = lifetime intake (pCi)
C = radionuclide concentration in exposure media (pCi/g, pCi/L),
CR = contact rate (g/d, L/d),
EF = exposure frequency (day/y), and
ED = exposure duration (y).

H.III.3 CRARE EXPOSURE MODELS

This section presents the equations used to quantify the magnitude of exposure expected to result from all reasonable exposure pathways at the FEMP. The calculations reflect changes in the risk assessment methodology resulting from revisions to the RAWPA (DOE 1992a) and comments received from the EPA and OEPA on the Operable Unit 1, 2, and 4 RI/FS risk assessments.

To quantify exposure as a result of residual COCs, several equations were used. This section presents the equations used according to exposure media. All parameters and equations were taken from the RAWPA and the Supplemental Guidance to RAWPA unless otherwise noted. The exposure media considered for residual risks are groundwater, air and soil. Exposure point concentrations were determined using fate and transport modeling in Section 3.0 of this CRARE. Exposures from sediment are included in the group detailing the soil exposure pathways. Exposure to surface water is addressed in the section detailing water exposure pathways. Equations for quantifying intake through the food pathway (e.r., ingestion of vegetables, fruit, milk, and meat) are provided. Contaminant concentrations in food products were developed in Attachment H.IV.1. The development of concentration terms for air, water, and soil are presented in Section H.3.0. These concentrations were used in conjunction with the following equations to quantify intake in attachment H.IV. The parameters used in the following equations are provided in Tables C.3-2 and C.3-3.

H.III.3.1 Air Exposure through Inhalation

The amount of a COC a receptor takes in as a result of respiration is a function of the concentration of the contaminant in the air. Equations 7-5 and 7-6 from the RAWPA were used to quantify intake from the inhalation pathway. These equations are as follows:

$$\text{(radionuclides)} \quad I_{ai} = (C_{ai})(IR)(EF)(ED) \quad \text{(H.III-14)}$$

$$\text{(chemicals)} \quad I_{ai} = (C_{ai})(IR)(EF)(ED)/(BW)(AT) \quad \text{(H.III-15)}$$

where

I_{ai} = intake from inhalation (pCi or mg/kg/d),
C_{ai} = concentration in air (pCi/m^3 or mg/m^3),
IR = inhalation rate (m^3/d),
EF = exposure frequency (d/y),
ED = exposure duration (y),

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BW = body weight (kg), and
AT = averaging time (d); for noncarcinogens, AT equals (ED)(365 d/y); for chemical carcinogens, AT equals (70)(365 d/y).

H.III.3.2 Water Exposures

This section discusses the quantification methodologies used to evaluate water exposures. Exposure pathways for water include ingestion and dermal contact.

Ingestion of Water

Ingestion of contaminated water can be a major contributor to environmental intake of COCs. An estimate of intake from water was calculated from Equations 7-3 and 7-4 of the RAWPA. The intake equations are:

$$\text{(radionuclides)} \quad I_{wi} = (C_{wi})(IR)(EF)(ED) \qquad \text{(H.III-16)}$$

$$\text{(chemicals)} \quad I_{wi} = (C_{wi})(IR)(EF)(ED)/(BW)(AT) \qquad \text{(H.III-17)}$$

where

I_{wi} = intake of ith contaminant from drinking water (pCi or mg/kg/d),
C_{wi} = i^{th} concentration in water (pCi/L or mg/L),
IR = ingestion rate (L/d),
EF = exposure frequency (d/y),
ED = exposure duration (y),
BW = body weight (kg), and
AT = averaging time (d); for noncarcinogens, AT equals (ED)(365 d/y) [EPA 1991a]); for chemical carcinogens, AT equals (70 y) (365 d/y).

Dermal Contact

The estimation of intake associated with inorganics in water via absorption though the skin was estimated using the concept of absorbed dose. The absorbed dose can be calculated using EPA's dermal guidance (EPA 1989a, EPA 1992b, and EPA 1993d). The dermal absorption pathway was evaluated for adults and children.

$$I_{ws} = (DA_{event})(EF)(ED)(SA)/(BW)(AT) \qquad \text{(H.III-18)}$$

where

I_{ws} = intake though dermal contact (mg/kg/d),
DA_{event} = absorbed dose per event (mg/cm^2/event),
SA = surface area (cm^2),
EF = exposure frequency (d/y),
ED = exposure duration (y),
BW = body weight (kg), and
AT = averaging time (d); for carcinogens, AT equals (ED)(365 d/y) [EPA 1989a]; for chemical carcinogens, AT equals (70y)(365 d/y).

DA_{event} can be calculated for inorganics as:

$$DA_{event} = (C_v)(K_p)(CF)(ET) \quad \text{(H.III-19)}$$

where

C_v = concentration of COC in the source (mg/L),
K_p = COC-specific permeability constant 10^{-3} (cm/h),
CF = unit conversion factor 10^{-3} (L/cm^3), and
ET = exposure time (h/d).

H.III.3.3 Soil and Sediment Exposures

The following sections discuss the quantification methodologies used to evaluate soil and sediment exposures.

Incidental Ingestion of Soil or Sediment

Evaluation of the soil/sediment ingestion pathway was performed using Equations 7-7 and 7-8 from the RAWPA:

$$\text{(radionuclides) } I_{si} = (C_{si})(IR)(FI)(EF)(ED) \quad \text{(H.III-20)}$$

$$\text{(chemicals) } I_{si} = (C_{si})(IR)(CF)(FI)(EF)(ED)/(BW)(AT) \quad \text{(H.III-21)}$$

where

I_{si} = intake from soil or sediment for COC (pCi or mg/kg/d),
C_{si} = concentration of COC in soil or sediment (pCi/mg or mg/kg),
IR = ingestion rate (mg/d),
CF = conversion factor 10^{-6} kg/mg,
FI = fraction ingested from contaminated source (unitless),
EF = exposure frequency (d/y),
ED = exposure duration (y),
BW = body weight (kg), and
AT = averaging time (d); for noncarcinogens, AT equals (ED)(365 d/y); for chemical carcinogens, AT equals (70 y)(365 d/y).

Dermal Contact with Soil or Sediment

Dermal absorption may also occur upon contact with contaminated soil and sediment and was calculated using Equation 7-25 of the RAWPA:

$$AB_{si} = (C_{si})(CF)(SA)(AF)(ABS)(ED)(EF)/(BW)(AT) \quad \text{(H.III-22)}$$

where

AB_{si} = amount of COC absorbed during contact with soil or sediment (mg/kg/d),
C_{si} = concentration of COC in soil or sediment (mg/kg),
SA = skin surface area available for contact (cm^2/event),
AF = skin adherence factor (mg/cm^2),

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ABS = absorption factor (unitless),
CF = conversion factor (10^{-6} kg/mg),
ED = exposure duration (y),
EF = exposure frequency (event/y),
BW = body weight (kg), and
AT = averaging time (d); for noncarcinogens, AT equals (ED)(365 d/y); for chemical carcinogens, AT equals (70 y/lifetime)(365 d/y).

Dermal absorption is not a significant pathway for radionuclides because penetration through the skin is minimal (EPA 1992c). Therefore, radionuclides were not quantified under this exposure pathway.

Direct Radiation Exposure

Since the publication of the RAWPA, the EPA has published a new set of radionuclide slope factors. Changes in these slope factors require the use of a different equation to calculate risks resulting from direct radiation exposures from soils than the original equation presented in the RAWPA. The new equation is:

$$DE = (C_s)(ED)(EF)(CF)[(ET_{in})(1-S_i) + (ET_{out})(1-S_o)] \quad \text{(H.III-23)}$$

where

DE = direct radiation exposure (pCi-y/g),
C_s = concentration in surface soil (pCi/g),
ED = exposure duration (y),
EF = exposure frequency (d/y),
ET_{in} = exposure time indoors on-property (h/d),
ET_{out} = exposure time outdoors on-property (h/d),
S_i = indoor shielding factor (unitless),
S_o = outdoor shielding factor outdoors (unitless), and
CF = 1/8760 y/h.

H.III.3.4 Food Products Exposure

This section presents the methodologies used to quantify intake through the food pathways (ingestion of vegetables, meat, and milk).

Ingestion of Vegetables

Evaluation of the vegetable ingestion pathway was performed using Equations 7-15 and 7-16 from the RAWPA:

$$\text{(radionuclides) } I_{iv} = (C_{iv})(IR)(ED)(EF)(FI) \quad \text{(H.III-24)}$$

$$\text{(chemicals) } I_{iv} = (C_{iv})(IR)(FI)(EF)(ED)/(BW)(AT) \quad \text{(H.III-25)}$$

where

I_{iv} = intake from vegetation (pCi or mg/kg/d),
C_{iv} = total concentration of COCs in vegetables or fruit (pCi/kg or mg/kg),
IR = ingestion rate (kg/day),

FI	=	fraction ingested from contaminated source (unitless),
EF	=	exposure frequency (d/y),
ED	=	exposure duration (y),
BW	=	body weight (kg), and
AT	=	averaging time (d); for noncarcinogens, AT equals (ED)(365 d/y); for carcinogens, AT equals (70-year lifetime)(365 d/y).

Ingestion of Meat, Milk, and Fish

Evaluation of the meat, milk, and fish ingestion pathways was performed using Equations 7-19 and 7-20 from the RAWPA:

$$\text{(radionuclides) } I_{Ai} = (C_{Ai})(IR)(ED)(EF)(FI) \qquad \text{(H.III-26)}$$

$$\text{(chemicals) } I_{Ai} = (C_{Ai})(IR)(FI)(EF)(ED)/(BW)(AT) \qquad \text{(H.III-27)}$$

where

I_{Ai}	=	intake from COC in food products (pCi or mg/kg/d),
C_{Ai}	=	concentration of COC in the animal product (pCi/L or mg/L for milk, pCi/kg or mg/kg for beef/fish)
IR	=	ingestion rate (L/d for milk; kg/d for beef/fish)
EF	=	exposure frequency(d/y)
ED	=	exposure duration (y),
FI	=	fraction ingested from contaminated source (unitless)
BW	=	body weight (kg),
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for carcinogens, AT equals (70-year lifetime)(365 d/y).

Table H.III-8 presents the residual-risk exposure parameters for the target and reference receptors. Table H.III-9 presents the calculated, chemical-specific dermal absorbed dose values for dermal soil exposures and dermal absorbed dose values for dermal water exposures. The media-specific exposure-point concentrations are presented in Table H.III-10.

TABLE H.III-8A

EXPOSURE PARAMETERS USED FOR TARGET RECEPTORS[a]

Pathway Parameter Units	Undeveloped Park User				Off-Property Resident	
	Child (1 to 6)	Youth (7 to 18)	Adult (19 to 55)	Senior Adult (56 to 70)	Farm (Adult) (1 to 70)	Farm (child) (1 to 6)
All pathways unless otherwise specified						
EF (d/y)	40	104	40	26	350	350
ED (y)	6	12	38	14	70	70
BW (kg)	15	43	70	70	70	15
$AT\text{-}_{noncarcinogenic}$ (d)	2190	4380	1370	5110	25550	2190
$AT\text{-}_{carcinogenic}$ (d)	25550	25550	25550	25550	25550	25550
Inhalation of dusts, volatiles, and radon						
IR (m^3/h)	0.83	0.83	0.83	0.83	0.83	0.5
ET (h/d)	1	2	2	1	24	24
Incidental ingestion of soils						
IR (g/d)	0.2	0.1	0.1	0.1	0.18	0.2
FI (unitless)	0.13	0.06	0.06	0.13	1	1
Dermal contact with soil						
SA (cm^2)	2000	4138	5750	5750	5750	2000
AF (mg/cm^2)	1.0	1.0	1.0	1.0	1.0	1.0
ABS (unitless)	CSV	CSV	CSV	CSV	CSV	CSV
External Radiation						
$ET_{indoors}$ (h/d)	NA	NA	NA	NA	18.3	22
$ET_{outdoors}$ (h/d)	1	2	2	1	5.7	2.0
$SH_{indoors}$ (unitless)	NA	NA	NA	NA	.5	.5
$SH\text{-}_{outdoors}$ (unitless)	0	0	0	0	0	0

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TABLE H.III-8A
(Continued)

Pathway Parameter Units	Undeveloped Park User Child (1 to 6)	Youth (7 to 18)	Adult (19 to 55)	Senior Adult (56 to 70)	Off-Property Resident Farm (Adult) (1 to 70)	Farm (child) (1 to 6)
Ingestion of drinking water						
IR (L/d)	NA	NA	NA	NA	1	2
Dermal contact while bathing						
SA (cm^2)	NA	NA	NA	NA	23,000	8000
DA (mg/cm^2-event)	NA	NA	NA	NA	CSV	CSV
ET (hr/event)	NA	NA	NA	NA	.25	.25
Incidental ingestion of surface water while wading						
IR (L/d)	NA	.035	NA	NA	NA	NA
ET (h/d)	NA	1	NA	NA	NA	NA
EF (h/d)	NA	52	NA	NA	NA	NA
ED (y)	NA	12	NA	NA	NA	NA
Dermal contact while wading						
SA (cm_2)	NA	5130	NA	NA	NA	NA
DA (mg/cm_2-event)	NA	CSV	NA	NA	NA	NA
EF (event/y)	NA	52	NA	NA	NA	NA
ED (y)	NA	12	NA	NA	NA	NA
ET (h/d)	NA	1	NA	NA	NA	NA
Ingestion of meat						
IR (kg/d)	NA	NA	NA	NA	0.1	0.039
FI (unitless)	NA	NA	NA	NA	0.75	0.75
Ingestion of dairy products						
IR (L/d)	NA	NA	NA	NA	0.4	0.9
FI (unitless)	NA	NA	NA	NA	0.75	0.75

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TABLE H.III-8A
(Continued)

Pathway Parameter Units	Undeveloped Park User				Off-Property Resident	
	Child (1 to 6)	Youth (7 to 18)	Adult (19 to 55)	Senior Adult (56 to 70)	Farm (Adult) (1 to 70)	Farm (child) (1 to 6)
Ingestion of fruits and vegetables						
IR (kg/d)	NA	NA	NA	NA	0.122	0.106
FI (unitless)	NA	NA	NA	NA	0.5	0.5
EF (d/y)	NA	NA	NA	NA	350	350
ED (y)	NA	NA	NA	NA	70	70

CSV - Chemical specific value
[a]All sources and assumptions for parameter values are explained in detail in the OU5 RI and/or the Supplemental Guidance to the FEMP RAWPA (DOE 1994g).

TABLE H.III-8B

EXPOSURE PARAMETERS FOR REFERENCE RECEPTOR[a]

Pathway Parameter Units	On-property RME adult (1-70)	On-property RME child (1-6)	Milk and meat consumer	Commercial/ Industrial user	Expanded Trespasser Youth (7-18)	Expanded Trespasser Adult (19-52)	Great Miami River User	Developed Park User Child (1 to 6)	Developed Park User Youth (7-18)	Developed Park User Adult (19-55)	Developed Park User Senior Adult (56-70)	Wildlife Reserve User Child (7-18)	Wildlife Reserve User Youth (7-18)	Wildlife Reserve User Adult (19-55)	Wildlife Reserve User Senior Adult (56-70)
All pathways unless otherwise specified															
EF (d/y)	350	350	350	250	110	40	350	64	104	40	40	26	39	52	26
ED (y)	70	6	70	25	12	32	70	6	12	38	14	6	12	38	14
BW (kg)	70	15	70	70	43	70	70	15	43	70	70	15	43	70	70
$AT_{noncarcinogenic}$ (d)	25550	2190	25550	9125	4380	11680	25550	2190	4380	13870	5110	2190	4380	13870	5110
$AT_{carcinogenic}$ (d)	25550	25550	25550	25550	2555	25550	25550	25550	2555	25550	25550	25550	25550	25550	25550
Inhalation of dusts, volatiles, and radon															
IR (m^3/day)	0.83	0.5	NA	0.83	0.83	0.83	NA	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
ET (h/d)	24	24	NA	24	2	1	NA	4	4	4	2	1	2	2	1
Incidental Ingestion of soils															
IR (g/d)	0.18	02	NA	0.1	0.1	0.1	NA	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1
FI (unitless)	1	1	NA	1	0.13	0.6	NA	0.25	0.25	0.25	0.13	0.06	0.13	0.13	0.06
Dermal contact with soil															
SA (cm^2)	5750	2000	NA	5750	4200	5750	NA	2000	4200	5750	5750	2000	4200	5750	5750
AF (mg/cm^2)	1.0	1.0	NA	1.0	1.0	1.0	NA	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ABS (umitless)	CSV	CSV	NA	CSV	CSV	CSV	NA	CSV	CSV	CSV	CSV	CSV	CSV	CSV	CSV
External Radiation															
$ET_{indoors}$ (h/d)	18.3	22	NA	6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
$ET_{outdoors}$ (h/d)	5.7	2.0	NA	4	2	1	NA	4	4	4	2	1	2	2	1
$SH_{indoors}$ (unitless)	0.5	0.5	NA	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
$SH_{outdoors}$ (unitless)	0	0	NA	0	0	0	NA	0	0	0	0	0	0	0	0
Ingestion of drinking water															
IR (L/d)	2.0	1.0	NA	NA	NA	NA	2.0	NA	NA	NA	NA	NA	NA	NA	NA
Dermal contact while bathing															
SA (cm^2)	23,000	8000	NA	NA	NA	NA	23,000	NA	NA	NA	NA	NA	NA	NA	NA
DA (mg/cm^2-event)	CSV	CSV	NA	NA	NA	NA	CSV	NA	NA	NA	NA	NA	NA	NA	NA
ET	.25	.25	NA	NA	NA	NA	.25	NA	NA	NA	NA	NA	NA	NA	NA

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TABLE H.III-8B
(Continued)

Pathway Parameter Units	On-property RME adult (1-70)	On-property RME child (1-6)	Milk and meat consumer	Commercial/ Industrial user	Expanded Trespasser Youth (7-18)	Expanded Trespasser Adult (19-52)	Great Miami River User	Developed Park User Child (1 to 6)	Developed Park User Youth (7-18)	Developed Park User Adult (19-55)	Developed Park User Senior Adult (56-70)	Wildlife Reserve User Child (7-18)	Wildlife Reserve User Youth (7-18)	Wildlife Reserve User Adult (19-55)	Wildlife Reserve User Senior Adult (56-70)
Incidental ingestion of surface water while wading or swimming															
IR (L/d)	NA	NA	NA	NA	.035	NA	0.05	NA	.035	NA	NA	NA	.035	NA	NA
ET (h/d)	NA	NA	NA	NA	1	NA	2.6	NA	1	NA	NA	NA	1	NA	NA
EF (d/y)	NA	NA	NA	NA	52	NA	7	NA	52	NA	NA	NA	52	NA	NA
ED (y)	NA	NA	NA	NA	12	NA	30	NA	12	NA	NA	NA	12	NA	NA
Dermal contact while wading or swimming															
SA (cm^2)	NA	NA	NA	NA	5130	NA	23,000	NA	5130	NA	NA	NA	5130	NA	NA
DA (mg/cm^2-event)	NA	NA	NA	NA	CSV	NA	CSV	NA	CSV	NA	NA	NA	CSV	NA	NA
EF (event/y)	NA	NA	NA	NA	52	NA	7	NA	52	NA	NA	NA	52	NA	NA
ET (h)	NA	NA	NA	NA	1	NA	2.6	NA	1	NA	NA	NA	1	NA	NA
Ingestion of meat															
IR (kg/d)	0.1	.039	0.1	NA	NA	NA	0.1	NA	NA	NA	NA	NA	NA	NA	NA
FI (unitless)	.75	.75	75	NA	NA	NA	.75	NA	NA	NA	NA	NA	NA	NA	NA
Ingestion of dairy products															
IR (L/d)	0.4	0.9	0.4	NA	NA	NA	0.4	NA	NA	NA	NA	NA	NA	NA	NA
FI (unitless)	.75	.75	.75	NA	NA	NA	.75	NA	NA	NA	NA	NA	NA	NA	NA
Ingestion of fruits and vegetables															
IR (kg/d)	.122	.106	NA	NA	NA	NA	.122	NA	NA	NA	NA	NA	NA	NA	NA
FI (unitless)	0.5	0.5	NA	NA	NA	NA	0.5	NA	NA	NA	NA	NA	NA	NA	NA
Ingestion of fish															
IR (kg/d)	NA	NA	NA	NA	NA	NA	.054	NA	NA	NA	NA	NA	NA	NA	NA
FI (unitless)	NA	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA
EF (d/y)	NA	NA	NA	NA	NA	NA	122	NA	NA	NA	NA	NA	NA	NA	NA
ED (y)	NA	NA	NA	NA	NA	NA	30	NA	NA	NA	NA	NA	NA	NA	NA

[a]Sources and assumptions for exposure parameters are discussed in the OU5 RI (DOE 1994) and/or the Supplemental Guidance to the FEMP RAWPA (DOE 1994g).
CSV - Chemical specific value

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TABLE H.III-9

DERMAL SOIL ABSORPTION COEFFICIENTS AND DERMAL WATER PERMEABILITY COEFFICIENT

COC	ABS	Kp
Inorganics		
Antimony	1.00×10^{-2}	1×10^{-3}
Arsenic	1.00×10^{-3}	1×10^{-3}
Beryllium	1.00×10^{-2}	1×10^{-3}
Cadmium	1.00×10^{-2}	1×10^{-3}
Magnesium	1.00×10^{-2}	1×10^{-3}
Manganese	1.00×10^{-2}	1×10^{-3}
Mercury	5.00×10^{-2}	1×10^{-3}
Silver	1.00×10^{-2}	1×10^{-3}
Uranium-Total	1.00×10^{-3}	1×10^{-3}
Organics		
1,2-dichloroethane	3.00×10^{-1}	5.3×10^{-3}
2,3,7,8-TCDD	3.00×10^{-2}	1.4×10^{0}
Benzo(a)pyrene	N/A[a]	1.2×10^{0}
Trichloroethene	3.00×10^{-1}	1.70×10^{-2}
Aroclor-1254	6.00×10^{-2}	7.1×10^{-1}
Aroclor-1260	6.00×10^{-2}	7.1×10^{-1}

SOURCE: OU2 RI report (DOE 1994a)

[a] Dermal Exposure to PAHs: Current policy indicates it is inappropriate to extrapolate dermal slope factors from oral slope factors for PAHs. Also, extrapolation from other routes of exposure is inappropriate due to varied absorption, metabolic transformations, and target organ end point responses. However, PAHs are potent skin carcinogens. Current information on the contribution to cancer risk from dermal exposure to PAHs indicates the toxicity from the dermal pathway may be as toxic as from oral route of exposure. To estimate the risk contribution from PAHs via dermal exposure for all direct contact pathways, the risk posed for dermal exposure was assumed equal to the risk from oral exposure.

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TABLE H.III-10

POSTREMEDIATION EXPOSURE POINT CONCENTRATIONS

Constituents of Concern	Farming On Site	On-Site Air Average	On-Site Soil	On-Site Groundwater	Off-Site Groundwater	On-Site Surface Water	Great Miami River	Off-Site Soil	Off-Site Air
Radionuclides									
Ra_{226+8d}	7.92×10^{-7}	1.42×10^{-7}	3.84×10^{-1}	3.28×10^{-10}	ND	1.45×10^{-3}	7.37×10^{-5}	ND	6.17×10^{-8}
Rn_{222}	1.07×10^{1}	1.84×10^{0}	ND	ND	ND	ND	ND	ND	8.00×10^{-1}
Sr_{90+1d}	7.90×10^{-8}	4.80×10^{-8}	1.19×10^{-1}	2.83×10^{-2}	5.36×10^{-6}	1.09×10^{0}	7.43×10^{-2}	1.50×10^{-2}	2.43×10^{-8}
Tc_{99}	1.59×10^{-7}	1.38×10^{-7}	2.50×10^{-1}	1.68×10^{1}	4.18×10^{-1}	ND	2.23×10^{0}	2.50×10^{-1}	3.34×10^{-7}
Th_{230}	8.43×10^{-7}	4.21×10^{-7}	6.45×10^{-1}	ND	ND	3.06×10^{-3}	1.23×10^{-3}	2.65×10^{-1}	2.43×10^{-7}
$Th_{232+10d}$	8.00×10^{-9}	4.00×10^{-9}	3.17×10^{-2}	ND	ND	1.66×10^{-4}	8.44×10^{-6}	ND	1.74×10^{-9}
$U_{235/236}$	ND	ND	ND	1.33×10^{-1}	8.29×10^{-2}	7.45×10^{-3}	6.61×10^{-4}	2.19×10^{-2}	4.95×10^{-9}
U_{238+2d}	3.18×10^{-6}	2.96×10^{-6}	2.27×10^{0}	3.01×10^{0}	1.87×10^{0}	1.68×10^{-1}	1.49×10^{-2}	1.32×10^{0}	1.58×10^{-6}
Inorganics/Organics									
Antimony	4.60×10^{-10}	ND	3.23×10^{-1}	ND	ND	1.04×10^{-4}	8.46×10^{-6}	ND	0.00
Aroclor-1254	5.27×10^{-11}	1.58×10^{-11}	2.46×10^{-2}	ND	ND	ND	ND	2.20×10^{-2}	1.18×10^{-11}
Aroclor-1260	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	3.10×10^{-10}	9.00×10^{-11}	1.92×10^{-1}	ND	ND	1.14×10^{-3}	ND	ND	3.91×10^{-11}
Beryllium	7.30×10^{-11}	1.40×10^{-11}	6.18×10^{-2}	ND	ND	2.38×10^{-3}	1.87×10^{-6}	ND	6.09×10^{-12}
Benzo(a)pyrene	1.28×10^{-11}	1.11×10^{-11}	2.00×10^{-2}	ND	ND	1.29×10^{-8}	7.08×10^{-9}	2.20×10^{-2}	9.35×10^{-12}
Cadmium	5.90×10^{-11}	1.60×10^{-11}	7.59×10^{-2}	ND	ND	ND	ND	ND	6.96×10^{-12}
1,2-dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Magnesium	4.48×10^{-6}	7.70×10^{-7}	2.82×10^{3}	ND	ND	ND	ND	2.63×10^{2}	3.94×10^{-7}
Manganese	2.00×10^{-9}	ND	ND	1.42×10^{-2}	ND	1.07×10^{-1}	ND	ND	ND
Mercury	ND	ND	ND	ND	ND	1.01×10^{-3}	8.18×10^{-5}	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,7,8-TCDD	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	7.70×10^{-13}	4.42×10^{-13}	7.55×10^{-4}	ND	ND	ND	ND	2.00×10^{-3}	6.43×10^{-13}
Uranium-total	9.51×10^{-9}	8.89×10^{-9}	8.30×10^{0}	8.61×10^{-3}	5.20×10^{-3}	ND	ND	3.93×10^{0}	4.75×10^{-9}

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ATTACHMENT IV

RISK CALCULATIONS

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H.IV RISK CALCULATIONS

Risk characterization is the final step in the CRARE process, combining the information developed in the toxicity assessment and the exposure assessment. Section H.IV.1 presents an overview of risk characterization and quantification methodologies for carcinogenic and noncarcinogenic compounds evaluated in this CRARE. A summary of risk by receptor and the detailed calculation tables can be found in Section H.IV.2. The risk results presented in this attachment reflect strictly the incremental risks associated with postremedial sources above background (radionuclides and inorganics). Total risk, that which is attributable to postremedial sources in addition to background, is presented in Attachment V of this report. Additionally, risks illustrating the impacts associated with postremedial sources plus inorganic background concentrations only are presented in Attachment V.

H.IV.1 RISK CHARACTERIZATION METHODOLOGY

In this CRARE, the potential risks to humans following exposure to postremediation residual COCs (radionuclides and nonradioactive chemicals) have been estimated using methods established by the EPA. The EPA has provided guidance documents and databases for characterizing human health risk, and these have been used as major sources in preparing CRARE risk assessments:

- Risk Assessment Guidance for Superfund (EPA 1989a)
- Integrated Risk Information System (EPA 1994a)
- Health Effects Assessment Summary Tables (EPA 1994b)
- Exposure Factors Handbook (EPA 1989d)

H.IV.1.1 Hazardous Chemical Exposures

Risks from nonradionuclide COCs have been estimated for carcinogenic and/or noncarcinogenic effects. Some carcinogens may also pose a noncarcinogenic toxic hazard. For those COCs that have an RfD available, the noncarcinogenic HQ was calculated. Effects due to exposures from these chemicals have been characterized for both types of health effects.

Risk Characterization Methodology for Carcinogens

The risk attributed to a carcinogen was estimated as the ILCR of an individual as a result of exposure to the contaminant. At low doses, the risk of developing cancer was estimated as follows (EPA 1989c):

$$\text{Risk} = (\text{CDI})(\text{SF}) \qquad \text{(H.IV-1)}$$

where

Risk = risk of cancer incidence, expressed as a unitless probability,
CDI = chronic daily intake averaged over 70 years (mg/kg/day), and

SF = slope factor $(mg/kg/day)^{-1}$.

For dermal exposure, cancer risks were calculated using adjusted toxicity factors based on absorbed doses of contaminants rather than contaminant intakes. For a given pathway with simultaneous exposure of a receptor to several carcinogens, the following equation was used to sum cancer risks:

$$Risk_p = Risk\ (chem_1) + Risk\ (chem_2) + \ldots Risk\ (chem_i) \qquad (H.IV\text{-}2)$$

where

$Risk_p$ = total pathway risk of cancer incidence, and
Risk $(chem_i)$ = risk associated with an individual carcinogenic chemical.

In compliance with EPA guidance (EPA 1989a), the ILCR values estimated in this CRARE for the potentially exposed receptor were compared to an incremental upper-bound lifetime cancer risk to an individual of 10^{-4} to 10^{-6}.

Risk Characterization Methodology for Noncarcinogens

The risk associated with exposure to noncarcinogenic hazardous COCs was evaluated by comparing an exposure level or intake to a RfD. It is recognized that this methodology for assessing the human-health effects of noncarcinogens does not give a measure of risk, per se (as is calculated for the carcinogens), but rather a ratio of intake to threshold limit. Even so, for convenience the term "risk" will continue to be used when discussing these evaluations. The ratio of intake/RfD for a single contaminant is the HQ and is defined as (EPA 1989a):

$$HQ = I/RfD \qquad (H.IV\text{-}3)$$

where

HQ = hazard quotient (unitless),
I = intake of a chemical (mg/kg/day), and
RfD = reference dose (mg/kg/day).

When using this equation to estimate potential noncarcinogenic risk, the intake and RfD must be derived from exposures of equivalent duration (e.g., subchronic, chronic, or fewer than two weeks). For this CRARE, COC exposures have been evaluated in all cases on a chronic basis, using chronic RfD values. Analogous to cancer risks, dermal noncancer risks were assessed using absorbed dose rather than intake.

In the case of simultaneous exposure of a receptor to several chemicals, an HI was calculated as the sum of the HQs by:

$$HI = I_i/RfD_1 + I_2/RfD_2 + \ldots I_i/RfD_i \qquad \text{(H.IV-4)}$$

where

HI	=	hazard index (unitless),
I_i	=	intake for the ith toxicant, and
RfD_i	=	reference dose for the ith toxicant.

The HI is an indicator of the potential for adverse effects associated with chronic exposures to multiple chemicals. In effect, HIs assume dose additivity for all COCs (EPA 1989a).

In compliance with EPA guidance (EPA 1989a), the noncarcinogenic HIs summed across pathways were compared to "unity." An HI of unity indicates that the exposure intake is equal to the RfD. If the HI is greater than 1 or "above unity," there is concern for potential health effects. Major categories of noncarcinogenic health effects include neurotoxicity, developmental toxicity, reproductive toxicity, immunotoxicity, and adverse effects on target organs, such as hepatic, renal, respiratory, cardiovascular, and dermal/ocular problems (EPA 1989a).

H.IV.1.2 Radiological Exposures

This section presents the procedures for estimating the total lifetime excess cancer risks due to exposure to radionuclides.

Risk Characterization Methodology for Internal Exposures

Risk characterization for internal exposures to radionuclides (intake via inhalation or ingestion) was calculated as follows (EPA 1989a):

$$Risk = (I)(SF) \qquad \text{(H.IV-5)}$$

where

Risk	=	risk of cancer incidence, expressed as a unitless probability,
I	=	lifetime radionuclide intake (pCi), and
SF	=	slope factor $(pCi)^{-1}$.

The slope factor is either a HEAST value for a particular radionuclide or the sum of the HEAST slope factors for that radionuclide and its short-lived progeny to account for ingrowth during storage and/or environmental transport.

Risk Characterization Methodology for External Gamma Exposures

For this CRARE, risk characterization for external exposure to gamma-emitting radionuclides in contaminated surface soil was calculated as follows (DOE 1992a):

$$Risk = (SF)[(C_s)(EF)(ED)(ET)(1 - SH)] \quad \text{(H.IV-6)}$$

where

Risk	=	risk of cancer incidence, expressed as a unitless probability,
C_s	=	radionuclide soil concentration (pCi/g),
SF	=	radionuclide slope factor (risk/yr/pCi/g) from EPA (1994a),
ET	=	fraction of day exposed (unitless),
ED	=	exposure duration (years),
EF	=	modifying factor, fraction of year exposed (unitless), and
SH	=	shielding factor (unitless).

External slope factors do not include contributions from decay products (radioactive progeny). In some cases, these contributions were substantial and required the inclusion of progeny in the overall risk calculation.

H.IV.2 INCREMENTAL HUMAN HEALTH RISKS

This section presents the risk and HI estimates for the target and reference receptors by pathway. Table H.IV-1 summarizes the total HI and ILCR for each receptor. Complete calculation sheets of the risk values can be found in Tables H.IV-2 through H.IV-120. The target receptors are presented first, followed by the reference receptors.

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TABLE H.IV-1

SUMMARY OF TOTAL ILCR AND HI FOR ALL RECEPTORS, CRARE APPROACH

Target Receptor	ILCR	HI
Undeveloped-Park User	2.2×10^{-6}	1.0×10^{-2}
Off-Property Farmer		
Adult	4.3×10^{-5}	1.6×10^{-1}
Child	1.7×10^{-5}	7.2×10^{-1}

Reference Receptor	ILCR	HI
On-Property Farmer		
Adult	2.1×10^{-4}	1.0×10^{0}
Child	3.5×10^{-5}	5.4×10^{0}
Commercial/Industrial User	2.9×10^{-5}	4.3×10^{-2}
Developed-Park User	4.8×10^{-6}	1.2×10^{-2}
Wildlife-Reserve User	1.9×10^{-6}	9.1×10^{-3}
Expanded Trespasser	1.5×10^{-6}	1.4×10^{-2}
Meat and Milk Consumer	3.3×10^{-5}	2.6×10^{-1}
Great Miami River User	7.7×10^{-7}	3.9×10^{-1}

Table H.IV–2
Summary of Risk Quantitation (chemicals)
Target Recptor: Undeveloped Park User
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	years
BWa	Body weight (adult)	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	days
ATa	Average time for non–carcinogens (adult)	2190	4380	13870	5110	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/m^3			mg/m^3
arodor–1254	1.6E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	9.0E–11	mg/m^3			mg/m^3
beryllium	1.4E–11	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E–11	mg/m^3			mg/m^3
cadmium	1.6E–11	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	7.7E–07	mg/m^3			mg/m^3
manganese		mg/m^3			mg/m^3
mercury		mg/m^3			mg/m^3
silver		mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E–13	mg/m^3			mg/m^3
uranium–total	8.9E–09	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.IV–2 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	NA	NA
aroclor–1254	6.3E–14	NA	NA
aroclor–1260	NA	NA	NA
arsenic	3.6E–13	NA	NA
beryllium	5.6E–14	NA	NA
benzo(a)pyrene	4.4E–14	NA	NA
cadmium	6.4E–14	NA	NA
1,2–dichloroethane	NA	2.9E–03	
magnesium	3.1E–09	NA	NA
manganese	NA	1.4E–05	
mercury	NA	8.6E–05	
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.8E–15	NA	NA
uranium–total	3.5E–11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	6.3E–14	NA	NA
aroclor–1260	NA	NA	NA
arsenic	3.6E–13	1.5E+01	5.4E–12
beryllium	5.6E–14	8.4E+00	4.7E–13
benzo(a)pyrene	4.4E–14	6.1E+00	2.7E–13
cadmium	6.4E–14	6.3E+00	4.0E–13
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	3.1E–09	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.8E–15	6.0E–03	1.1E–17
uranium–total	3.5E–11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			6.5E–12

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Table H.IV–3
Summary of Risk Quantitation (radionuclides)
Target Receptor: Undeveloped Park User
Via Inhalation of Gases and Particulates

Risk Equation = CA X EF X ED X IR X ET

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ED	Exposure duration	6	12	38	14	years
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	40	104	40	26	days/year
CA	Concentration of radionuclides in air	csv	csv	csv	csv	

Ra_{226+8d}	1.4E–07	pCi/m^3		pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3		pCi/m^3
Sr_{90+1d}	4.8E–08	pCi/m^3		pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3		pCi/m^3
Th_{230}	4.2E–07	pCi/m^3		pCi/m^3
$Th_{232+10d}$	4.0E–09	pCi/m^3		pCi/m^3
$U_{235/236}$		pCi/m^3		pCi/m^3
U_{238+2d}	3.0E–06	pCi/m^3		pCi/m^3
		pCi/m^3		pCi/m^3
		pCi/m^3		pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	7.2E–04	7.0E–09	5.1E–12
Rn_{222}	9.4E+03	7.3E–13	6.8E–09
Sr_{90+1d}	2.4E–04	6.2E–11	1.5E–14
Tc_{99}	7.0E–04	8.3E–12	5.8E–15
Th_{230}	2.1E–03	2.9E–08	6.2E–11
$Th_{232+10d}$	2.0E–05	1.1E–07	2.2E–12
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	1.5E–02	2.4E–08	3.6E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		7.3E–09

Table H.IV-4
Summary of Risk Quantitation (chemicals)
Target Recptor: Undeveloped Park User
Via Incidental Ingestion of Soil/Sediment

Risk Equation $= \frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E-06	1E-06	1E-06	1E-06	kg/mg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non-carcinogens	2190	4380	13870	5110	day
BW	Body weight	15	43	70	70	kg
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.2E-01	mg/kg			mg/kg
aroclor-1254	2.5E-02	mg/kg			mg/kg
aroclor-1260		mg/kg			mg/kg
arsenic	1.9E-01	mg/kg			mg/kg
beryllium	6.2E-02	mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium	7.6E-02	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	2.8E+03	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	7.6E-04	mg/kg			mg/kg
uranium-total	8.3E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-4 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.1E-08	4.0E-04	2.8E-05
aroclor-1254	8.5E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.6E-09	3.0E-04	2.2E-05
beryllium	2.1E-09	5.0E-03	4.3E-07
benzo(a)pyrene	6.9E-10	NA	NA
cadmium	2.6E-09	1.0E-03	2.6E-06
1,2-dichloroethane	NA	NA	NA
magnesium	9.7E-05	9.7E+00	1.0E-05
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.6E-11	6.0E-03	4.3E-09
uranium-total	2.9E-07	3.0E-03	9.6E-05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.6E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.1E-08	NA	NA
aroclor-1254	8.5E-10	7.7E+00	6.5E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	6.6E-09	1.8E+00	1.2E-08
beryllium	2.1E-09	4.3E+00	9.2E-09
benzo(a)pyrene	6.9E-10	7.3E+00	5.0E-09
cadmium	2.6E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	9.7E-05	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.6E-11	1.1E-02	2.9E-13
uranium-total	2.9E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.2E-08

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Table H.IV–5
Summary of Risk Quantitation (radionuclides)
Target Recptor: Undeveloped Park User
Via Incidental Ingestion of Soil/Sediment

Risk Equation = CS X EF X ED X FI X IR

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	year
FI	Fractional Intake	1	1	1	1	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Ra_{226+8d}	3.8E–04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.2E–04	pCi/mg	pCi/mg
Tc_{99}	2.5E–04	pCi/mg	pCi/mg
Th_{230}	6.5E–04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.2E–05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.8E–03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E–05	7.8E–10	1.2E–14
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	4.9E–06	3.6E–11	1.8E–16
Tc_{99}	1.0E–05	1.3E–12	1.3E–17
Th_{230}	2.6E–05	1.3E–11	3.4E–16
$Th_{232+10d}$	1.3E–06	1.7E–10	2.2E–16
$U_{235/236}$	NA	1.6E–11	NA
U_{238+2d}	1.1E–04	2.0E–11	2.3E–15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.5E–14

Table H.IV–6
Summary of Risk Quantitation (chemicals)
Target Recptor: Undeveloped Park User
Via Dermal Contact with Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		child	youth	adult	senoir adult
SA	Surface area of exposed skin	2000	4138	5750	5750 cm^2/day
AF	Absorbtion factor	csv	csv	csv	csv (unitless)
EF	Exposure frequency	40	104	40	26 days/year
ED	Exposure duration	6	12	38	14 year
CF	Conversion factor	1E–06	1.000E–06	1E–06	1E–06 kg/mg
BW	Body weight	15	43	70	70 kg
AT	Average time for carcinogens	25550	25550	25550	25550 day
AT	Average time for non–carcinogens	2190	4380	13870	5110 day
ABS	Absorbtion factor	csv	csv	csv	csv (unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv

Chemical Concentrations

Compound	ABS	Concentration	Units
antimony	1.0E–02	3.2E–01	mg/kg
arodor–1254	6.0E–02	2.5E–02	mg/kg
arodor–1260	6.0E–02		mg/kg
arsenic	1.0E–03	1.9E–01	mg/kg
beryllium	1.0E–02	6.2E–02	mg/kg
benzo(a)pyrene	3.0E–01	2.0E–02	mg/kg
cadmium	1.0E–02	7.6E–02	mg/kg
1,2–dichloroethane	3.0E–01		mg/kg
magnesium	1.0E–02	2.8E+03	mg/kg
manganese	1.0E–02		mg/kg
mercury	5.0E–02		mg/kg
silver	1.0E–02		mg/kg
2,3,7,8–tcdd	3.0E–02		mg/kg
trichloroethene	3.0E–01	7.6E–04	mg/kg
uranium–total	1.0E–02	8.3E+00	mg/kg
	NA		mg/kg

Compound	ABS	Concentration	Units
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg

References

000215

Table H.IV–6 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	3.9E–08	6.0E–05	6.5E–04
aroclor–1254	1.8E–08	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.3E–09	2.9E–04	8.1E–06
beryllium	7.4E–09	5.0E–03	1.5E–06
benzo(a)pyrene	7.2E–08	NA	NA
cadmium	9.1E–09	5.0E–05	1.8E–04
1,2–dichloroethane	NA	NA	NA
magnesium	3.4E–04	4.9E–01	7.0E–04
manganese	NA	4.2E–03	NA
mercury	NA	4.5E–05	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	2.7E–09	5.9E–03	4.6E–07
uranium–total	1.0E–06	1.5E–04	6.6E–03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		8.2E–03

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	3.9E–08	NA	NA
aroclor–1254	1.8E–08	1.0E+01	1.8E–07
aroclor–1260	NA	1.0E+01	NA
arsenic	2.3E–09	1.8E+00	4.2E–09
beryllium	7.4E–09	4.3E+00	3.2E–08
benzo(a)pyrene	7.2E–08	NA	NA
cadmium	9.1E–09	NA	NA
1,2–dichloroethane	NA	1.0E–01	NA
magnesium	3.4E–04	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.0E+05	NA
trichloroethene	2.7E–09	1.1E–02	3.1E–11
uranium–total	1.0E–06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.2E–07

000246

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Table H.IV-7
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Ingestion While Wading

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non-carcinogens	2190	4380	13870	5110	days
CS	Concentration of chemicals in surface water	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E-04	mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	1.14E-03	mg/l			mg/l
beryllium	2.38E-05	mg/l			mg/l
benzo(a)pyrene	1.29E-08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium		mg/l			mg/l
manganese	1.07E-01	mg/l			mg/l
mercury	1.01E-03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total		mg/l			mg/l
		mg/l			

References

000237

Table H.IV-7 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.07E-09	4.00E-04	5.17E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.27E-08	3.00E-04	7.55E-05
beryllium	4.73E-10	5.00E-03	9.46E-08
benzo(a)pyrene	2.56E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	NA
manganese	2.13E-06	5.00E-03	4.25E-04
mercury	2.01E-08	3.00E-04	6.69E-05
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	NA	3.00E-03	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.73E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.17E-08

000178

Table H.IV–8
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact While Wading

Risk Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	*Average time for carcinogens*		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
SA	Skin surface area		5130			cm^2
DA	chemicals specific dermal absorbed dose	csv	csv	csv	csv	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E–09	mg/cm^2–day			mg/cm^2–day
arodor–1254		mg/cm^2–day			mg/cm^2–day
arodor–1260		mg/cm^2–day			mg/cm^2–day
arsenic	1.14E–08	mg/cm^2–day			mg/cm^2–day
beryllium	2.38E–10	mg/cm^2–day			mg/cm^2–day
benzo(a)pyrene	7.29E–10	mg/cm^2–day			mg/cm^2–day
cadmium		mg/cm^2–day			mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day			mg/cm^2–day
magnesium		mg/cm^2–day			mg/cm^2–day
manganese	1.07E–06	mg/cm^2–day			mg/cm^2–day
mercury	1.01E–08	mg/cm^2–day			mg/cm^2–day
silver		mg/cm^2–day			mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day			mg/cm^2–day
trichloroethene		mg/cm^2–day			mg/cm^2–day
uranium–total		mg/cm^2–day			mg/cm^2–day
		mg/cm^2–day			

References

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Table H.IV-8 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.03E-09	6.00E-05	5.05E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.32E-08	2.85E-04	1.17E-04
beryllium	6.93E-10	5.00E-03	1.39E-07
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	4.85E-01	NA
manganese	3.12E-06	4.20E-03	7.42E-04
mercury	2.94E-08	4.50E-05	6.54E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	NA	1.50E-04	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.56E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	NA	NA	NA
manganese	3.12E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.42E-08

000320

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Table H.IV-9
Summary of Risk Quantitation (radionuclides)
Target Recptor: Undeveloped Park User
Via Incidental Ingestion while Wading

Risk Equation = CS X EF X ED X IRsw

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
Cs	Concentration of radionuclides in surface water	csv	csv	csv	csv	

Ra_{226+8d}	1.5E-03	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	1.1E+00	pCi/l	pCi/l
Tc_{99}		pCi/l	pCi/l
Th_{230}	3.1E-03	pCi/l	pCi/l
$Th_{232+10d}$	1.7E-04	pCi/l	pCi/l
$U_{235/236}$	7.5E-03	pCi/l	pCi/l
U_{238+2d}	1.7E-01	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.2E-02	7.8E-10	2.5E-11
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	2.4E+01	3.6E-11	8.6E-10
Tc_{99}	NA	1.3E-12	NA
Th_{230}	6.7E-02	1.3E-11	8.7E-13
$Th_{232+10d}$	3.6E-03	1.7E-10	6.2E-13
$U_{235/236}$	1.6E-01	1.6E-11	2.6E-12
U_{238+2d}	3.7E+00	2.0E-11	7.3E-11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 9.6E-10

Table H.IV-10
Summary of Risk Quantitation (radionuclides)
Target Receptor: Undeveloped Park User
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]+[CR \times EF \times ED \times ET_i \times (1-SH_i)]$

		child	youth	adult	senoir adult	
EF	Fraction of year spent exposured	0.11	0.28	0.11	0.07	(unitless)
ED	Exposure duration	6	12	38	14	years
ET_o	Fraction of day spent outdoors	0.04	0.08	0.08	0.04	(unitless)
ET_i	Fraction of day spent indoors	NA	NA	NA	NA	NA
SH_i	Shield factor indoors	0.5	0.5	0.5	0.5	(unitless)
SH_o	Shield factor outdoors					(unitless)
CR	Radionuclide specific concentrations	csv	csv	csv	csv	

Ra_{226+8d}	3.8E-01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.2E-01	pCi/g	NA	pCi/g
Tc_{99}	2.5E-01	pCi/g	NA	pCi/g
Th_{230}	6.5E-01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.2E-02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.8E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.6E-01	6.0E-06	1.5E-06
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	8.0E-02	NA	NA
Tc_{99}	1.7E-01	6.0E-13	1.0E-13
Th_{230}	4.3E-01	5.4E-11	2.3E-11
$Th_{232+10d}$	2.1E-02	8.5E-06	1.8E-07
$U_{235/236}$	NA	2.4E-07	NA
U_{238+2d}	1.9E+00	5.1E-08	9.4E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.8E-06

Table II.IV – 11
Summary of Risk Quantitation (chemicals)
Target Receptor: Off – Property Farm Resident (Adult)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non – carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non – carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
antimony		mg/m^3
arodor – 1254	1.2E – 11	mg/m^3
arodor – 1260		mg/m^3
arsenic	3.9E – 11	mg/m^3
beryllium	6.1E – 12	mg/m^3
benzo(a)pyrene	9.3E – 12	mg/m^3
cadmium	7.0E – 12	mg/m^3
1,2 – dichloroethane		mg/m^3
magnesium	3.9E – 07	mg/m^3
manganese		mg/m^3
mercury		mg/m^3
silver		mg/m^3
2,3,7,8 – tcdd		mg/m^3
trichloroethene	6.4E – 13	mg/m^3
uranium – total	4.8E – 09	mg/m^3
		mg/m^3

Compound	Concentration	Units
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3

References

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Table H.IV-11 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	NA	NA
aroclor-1254	3.2E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.1E-11	NA	NA
beryllium	1.7E-12	NA	NA
benzo(a)pyrene	2.6E-12	NA	NA
cadmium	1.9E-12	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	1.1E-07	NA	NA
manganese	NA	1.4E-05	NA
mercury	NA	8.6E-05	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.8E-13	NA	NA
uranium-total	1.3E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	3.2E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.1E-11	1.5E+01	1.6E-10
beryllium	1.7E-12	8.4E+00	1.4E-11
benzo(a)pyrene	2.6E-12	6.1E+00	1.6E-11
cadmium	1.9E-12	6.3E+00	1.2E-11
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.1E-07	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.8E-13	6.0E-03	1.1E-15
uranium-total	1.3E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.0E-10

000224

Table H.IV–12
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		20 m^3/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		70 Year
Ca	Concentration of radionuclides in air		(see table below)

Ra_{226+8d}	6.2E–08	pCi/m^3	pCi/m^3
Rn_{222}	8.0E–01	pCi/m^3	pCi/m^3
Sr_{90+1d}	2.4E–08	pCi/m^3	pCi/m^3
Tc_{99}	3.3E–07	pCi/m^3	pCi/m^3
Th_{230}	2.4E–07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	1.7E–09	pCi/m^3	pCi/m^3
$U_{235/236}$	5.0E–09	pCi/m^3	pCi/m^3
U_{238+2d}	1.6E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.0E–02	7.0E–09	2.1E–10
Rn_{222}	3.9E+05	7.3E–13	2.9E–07
Sr_{90+1d}	1.2E–02	6.2E–11	7.4E–13
Tc_{99}	1.6E–01	8.3E–12	1.4E–12
Th_{230}	1.2E–01	2.9E–08	3.5E–09
$Th_{232+10d}$	8.5E–04	1.1E–07	9.4E–11
$U_{235/236}$	2.4E–03	2.5E–08	6.1E–11
U_{238+2d}	7.8E–01	2.4E–08	1.9E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		3.1E–07

Table H.IV – 13
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	180	mg/day
CF	Conversion factor	1.0E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in soil	(see table below)	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/kg			mg/kg
arodor–1254	2.2E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic		mg/kg			mg/kg
beryllium		mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium		mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.6E+02	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	2.0E–03	mg/kg			mg/kg
uranium–total	3.9E+00	mg/kg			mg/kg
		mg/kg			

References

Table H.IV-13 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	
aroclor-1254	5.4E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.0E-04	
beryllium	NA	5.0E-03	
benzo(a)pyrene	4.9E-08	NA	NA
cadmium	NA	1.0E-03	
1,2-dichloroethane	NA	NA	NA
magnesium	6.5E-04	9.7E+00	6.7E-05
manganese	NA	1.4E-01	
mercury	NA	3.0E-04	
silver	NA	5.0E-03	
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-09	6.0E-03	8.2E-07
uranium-total	9.7E-06	3.0E-03	3.2E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.3E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	5.4E-08	7.7E+00	4.2E-07
aroclor-1260	NA	7.7E+00	
arsenic	NA	1.8E+00	
beryllium	NA	4.3E+00	
benzo(a)pyrene	4.9E-08	7.3E+00	3.6E-07
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	6.5E-04	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	4.9E-09	1.1E-02	5.4E-11
uranium-total	9.7E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		7.8E-07

000327

Table H.IV-14
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	70 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}		pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.50E-05	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	2.65E-04	pCi/mg	pCi/mg
$Th_{232+10d}$		pCi/mg	pCi/mg
$U_{235/236}$	2.19E-05	pCi/mg	pCi/mg
U_{238+2d}	1.32E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	7.80E-10	NA
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	6.62E+01	3.60E-11	2.38E-09
Tc_{99}	1.10E+03	1.30E-12	1.43E-09
Th_{230}	1.17E+03	1.30E-11	1.52E-08
$Th_{232+10d}$	NA	1.70E-10	NA
$U_{235/236}$	9.66E+01	1.60E-11	1.55E-09
U_{238+2d}	5.82E+03	2.00E-11	1.16E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.37E-07

Table H.IV–15
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E–02		mg/kg		NA	mg/kg
arodor–1254	6.00E–02	2.20E–02	mg/kg		NA	mg/kg
arodor–1260	6.00E–02		mg/kg		NA	mg/kg
arsenic	1.00E–03		mg/kg		NA	mg/kg
beryllium	1.00E–02		mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E–01	2.00E–02	mg/kg		NA	mg/kg
cadmium	1.00E–02		mg/kg		NA	mg/kg
1,2–dichloroethane	3.00E–01		mg/kg		NA	mg/kg
magnesium	1.00E–02	2.63E+02	mg/kg		NA	mg/kg
manganese	1.00E–02		mg/kg		NA	mg/kg
mercury	5.00E–02		mg/kg		NA	mg/kg
silver	1.00E–02		mg/kg		NA	mg/kg
2,3,7,8–tcdd	3.00E–02		mg/kg		NA	mg/kg
trichloroethene	3.00E–01	2.00E–03	mg/kg		NA	mg/kg
uranium–total	1.00E–02	3.93E+00	mg/kg		NA	mg/kg
	NA		mg/kg			

References

623000

Table H.IV-15 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	6.00E-05	
aroclor-1254	1.04E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	2.85E-04	
beryllium	NA	5.00E-03	
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	NA	5.00E-05	
1,2-dichloroethane	NA	NA	NA
magnesium	2.07E-04	4.85E-01	4.27E-04
manganese	NA	4.20E-03	
mercury	NA	4.50E-05	
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.73E-08	5.88E-03	8.04E-06
uranium-total	3.10E-06	1.50E-04	2.06E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.11E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	1.04E-07	1.03E+01	1.07E-06
aroclor-1260	NA	1.03E+01	
arsenic	NA	1.84E+00	
beryllium	NA	4.30E+00	
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	2.07E-04	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	4.73E-08	1.12E-02	5.30E-10
uranium-total	3.10E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.07E-06

000330

Table H.IV – 16
Summary of Risk Quantitation (chemicals)
Target Receptor: Off – Property Farm Resident (Adult)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non – carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non – carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor – 1254		mg/l			mg/l
arodor – 1260		mg/l			mg/l
arsenic		mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2 – dichloroethane		mg/l			mg/l
magnesium		mg/l			mg/l
manganese		mg/l			mg/l
mercury		mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8 – tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium – total	5.20E – 03	mg/l			mg/l
		mg/l			

References

000121

Table H.IV–16 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	4.00E–04	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	NA	3.00E–04	NA
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E–03	NA
1,2–dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	NA
manganese	NA	5.00E–03	NA
mercury	NA	3.00E–04	NA
silver	NA	5.00E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	6.00E–03	NA
uranium–total	1.42E–04	3.00E–03	4.75E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.75E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	7.70E+00	NA
aroclor–1260	NA	7.70E+00	NA
arsenic	NA	1.75E+00	NA
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	9.10E–02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E–02	NA
uranium–total	1.42E–04	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		

000332

Table H.IV–17
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)		2 l/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		70 Year
FI	Fractional Intake for radionuclides		1 (Unitless)
Cw	Concentration of radionuclides in groundwater		(see table below)

Ra_{226+8d}		pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	5.4E–06	pCi/l	pCi/l
Tc_{99}	4.2E–01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	8.3E–02	pCi/l	pCi/l
U_{238+2d}	1.9E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	7.8E–10	NA
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.6E–01	3.6E–11	9.5E–12
Tc_{99}	2.0E+04	1.3E–12	2.7E–08
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	4.1E+03	1.6E–11	6.5E–08
U_{238+2d}	9.2E+04	2.0E–11	1.8E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.9E–06

Table H.IV – 18
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	25550	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1254	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1260	NA	mg/cm^2–day		NA	mg/cm^2–day
arsenic	NA	mg/cm^2–day		NA	mg/cm^2–day
beryllium	NA	mg/cm^2–day		NA	mg/cm^2–day
benzo(a)pyrene	NA	mg/cm^2–day		NA	mg/cm^2–day
cadmium	NA	mg/cm^2–day		NA	mg/cm^2–day
1,2–dichloroethane	NA	mg/cm^2–day		NA	mg/cm^2–day
magnesium	NA	mg/cm^2–day		NA	mg/cm^2–day
manganese	NA	mg/cm^2–day		NA	mg/cm^2–day
mercury	NA	mg/cm^2–day		NA	mg/cm^2–day
silver	NA	mg/cm^2–day		NA	mg/cm^2–day
2,3,7,8–tcdd	NA	mg/cm^2–day		NA	mg/cm^2–day
trichloroethene	NA	mg/cm^2–day		NA	mg/cm^2–day
uranium–total	1.30E–08	mg/cm^2–day		NA	mg/cm^2–day
	NA	mg/cm^2–day			

References

000334

6349

Table H.IV-18 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	6.00E-05	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	2.85E-04	NA
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	4.85E-01	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	4.09E-06	1.50E-04	2.73E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.73E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	NA	1.84E+00	NA
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	4.09E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		

000353

Table H.IV – 19
Summary of Risk Quantitation (chemicals)
Target Receptor: Off – Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non – carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non – carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/kg			mg/kg
arodor – 1254	6.7E–07	mg/kg			mg/kg
arodor – 1260		mg/kg			mg/kg
arsenic	2.8E–11	mg/kg			mg/kg
beryllium	1.4E–12	mg/kg			mg/kg
benzo(a)pyrene	6.8E–07	mg/kg			mg/kg
cadmium	2.6E–11	mg/kg			mg/kg
1,2 – dichloroethane		mg/kg			mg/kg
magnesium	6.6E–02	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8 – tcdd		mg/kg			mg/kg
trichloroethene	1.0E–09	mg/kg			mg/kg
uranium – total	7.8E–07	mg/kg			mg/kg
		mg/kg			

References

000236

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Table H.IV-19 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
aroclor-1254	6.9E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.8E-14	3.0E-04	9.5E-11
beryllium	1.5E-15	5.0E-03	2.9E-13
benzo(a)pyrene	7.0E-10	NA	NA
cadmium	2.6E-14	1.0E-03	2.6E-11
1,2-dichloroethane	NA	NA	NA
magnesium	6.8E-05	9.7E+00	7.0E-06
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.0E-12	6.0E-03	1.7E-10
uranium-total	8.0E-10	3.0E-03	2.7E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		7.3E-06

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	6.9E-10	7.7E+00	5.3E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	2.8E-14	1.8E+00	5.0E-14
beryllium	1.5E-15	4.3E+00	6.2E-15
benzo(a)pyrene	7.0E-10	7.3E+00	5.1E-09
cadmium	2.6E-14	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	6.8E-05	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.0E-12	1.1E-02	1.1E-14
uranium-total	8.0E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.0E-08

000257

Table H.IV–20
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	3.8E–09	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	5.6E–04	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	8.6E–07	pCi/kg	pCi/kg
$Th_{232+10d}$	9.5E–13	pCi/kg	pCi/kg
$U_{235/236}$	4.9E–06	pCi/kg	pCi/kg
U_{238+2d}	2.6E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.9E–06	7.8E–10	5.4E–15
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.0E+00	3.6E–11	3.7E–11
Tc_{99}	1.9E+03	1.3E–12	2.4E–09
Th_{230}	1.6E–03	1.3E–11	2.1E–14
$Th_{232+10d}$	1.7E–09	1.7E–10	3.0E–19
$U_{235/236}$	9.0E–03	1.6E–11	1.4E–13
U_{238+2d}	4.8E–01	2.0E–11	9.7E–12
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.5E–09

Table H.IV–21
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/kg			mg/kg
arodor–1254	2.1E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	8.3E–10	mg/kg			mg/kg
beryllium	1.3E–12	mg/kg			mg/kg
benzo(a)pyrene	2.2E–04	mg/kg			mg/kg
cadmium	4.7E–08	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	5.3E+01	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.2E–07	mg/kg			mg/kg
uranium–total	2.4E–03	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV–21 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	4.0E–04	NA
aroclor–1254	8.7E–07	NA	NA
aroclor–1260	NA	NA	NA
arsenic	3.4E–12	3.0E–04	1.1E–08
beryllium	5.2E–15	5.0E–03	1.0E–12
benzo(a)pyrene	8.8E–07	NA	NA
cadmium	1.9E–10	1.0E–03	1.9E–07
1,2–dichloroethane	NA	NA	NA
magnesium	2.2E–01	9.7E+00	2.3E–02
manganese	NA	1.4E–01	NA
mercury	NA	3.0E–04	NA
silver	NA	5.0E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.3E–09	6.0E–03	2.2E–07
uranium–total	9.7E–06	3.0E–03	3.2E–03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.6E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	8.7E–07	7.7E+00	6.7E–06
aroclor–1260	NA	7.7E+00	NA
arsenic	3.4E–12	1.8E+00	6.0E–12
beryllium	5.2E–15	4.3E+00	2.2E–14
benzo(a)pyrene	8.8E–07	7.3E+00	6.5E–06
cadmium	1.9E–10	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	2.2E–01	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.3E–09	1.1E–02	1.4E–11
uranium–total	9.7E–06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.3E–05

000340

Table H.IV-22
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	6.8E-06	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.8E+00	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	7.2E-04	pCi/kg	pCi/kg
$Th_{232+10d}$	7.9E-10	pCi/kg	pCi/kg
$U_{235/236}$	1.5E-02	pCi/kg	pCi/kg
U_{238+2d}	8.0E-01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	5.0E-02	7.8E-10	3.9E-11
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	2.1E+04	3.6E-11	7.5E-07
Tc_{99}	8.7E+06	1.3E-12	1.1E-05
Th_{230}	5.3E+00	1.3E-11	6.9E-11
$Th_{232+10d}$	5.8E-06	1.7E-10	9.8E-16
$U_{235/236}$	1.1E+02	1.6E-11	1.8E-09
U_{238+2d}	5.9E+03	2.0E-11	1.2E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.2E-05

Table H.IV–23
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/kg			mg/kg
arodor–1254	2.8E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	2.6E–07	mg/kg			mg/kg
beryllium	2.5E–08	mg/kg			mg/kg
benzo(a)pyrene	2.3E–04	mg/kg			mg/kg
cadmium	9.3E–07	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.6E+02	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.2E–03	mg/kg			mg/kg
uranium–total	5.9E–02	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-23 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
aroclor-1254	2.3E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.1E-10	3.0E-04	7.1E-07
beryllium	2.1E-11	5.0E-03	4.2E-09
benzo(a)pyrene	1.9E-07	NA	NA
cadmium	7.8E-10	1.0E-03	7.8E-07
1,2-dichloroethane	NA	NA	NA
magnesium	2.2E-01	9.7E+00	2.3E-02
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.7E-06	6.0E-03	4.4E-04
uranium-total	4.9E-05	3.0E-03	1.6E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			3.9E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	2.3E-07	7.7E+00	1.8E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	2.1E-10	1.8E+00	3.7E-10
beryllium	2.1E-11	4.3E+00	9.0E-11
benzo(a)pyrene	1.9E-07	7.3E+00	1.4E-06
cadmium	7.8E-10	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	2.2E-01	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.7E-06	1.1E-02	2.9E-08
uranium-total	4.9E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			3.2E-06

000343

Table H.IV–24
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	2.7E–04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	3.7E+01	pCi/kg	pCi/kg
Tc_{99}	2.4E+03	pCi/kg	pCi/kg
Th_{230}	2.3E–01	pCi/kg	pCi/kg
$Th_{232+10d}$	2.2E–06	pCi/kg	pCi/kg
$U_{235/236}$	5.9E–01	pCi/kg	pCi/kg
U_{238+2d}	2.0E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	4.0E–01	7.8E–10	3.1E–10
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	5.6E+04	3.6E–11	2.0E–06
Tc_{99}	3.6E+06	1.3E–12	4.6E–06
Th_{230}	3.4E+02	1.3E–11	4.4E–09
$Th_{232+10d}$	3.3E–03	1.7E–10	5.7E–13
$U_{235/236}$	8.8E+02	1.6E–11	1.4E–08
U_{238+2d}	3.0E+04	2.0E–11	6.1E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		7.3E–06

Table H.IV–25
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	70 Year
ET_i	Fraction of day spent indoors	0.76 (unitless)
ET_o	Fraction of day spent outdoors	0.24 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	NA	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.50E–02	pCi/g	NA	pCi/g
Tc_{99}	2.50E–01	pCi/g	NA	pCi/g
Th_{230}	2.65E–01	pCi/g	NA	pCi/g
$Th_{232+10d}$	NA	pCi/g	NA	pCi/g
$U_{235/236}$	2.19E–02	pCi/g	NA	pCi/g
U_{238+2d}	1.32E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	6.0E–06	NA
Rn_{222}	NA	1.2E–09	NA
Sr_{90+1d}	6.2E–01	NA	
Tc_{99}	1.0E+01	6.0E–13	6.2E–12
Th_{230}	1.1E+01	5.4E–11	6.0E–10
$Th_{232+10d}$	NA	8.5E–06	NA
$U_{235/236}$	9.1E–01	2.4E–07	2.2E–07
U_{238+2d}	5.5E+01	5.1E–08	2.8E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		3.0E–06

Table H.IV–26
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/m^3			mg/m^3
arodor–1254	1.2E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	3.9E–11	mg/m^3			mg/m^3
beryllium	6.1E–12	mg/m^3			mg/m^3
benzo(a)pyrene	9.3E–12	mg/m^3			mg/m^3
cadmium	7.0E–12	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	3.9E–07	mg/m^3			mg/m^3
manganese		mg/m^3			mg/m^3
mercury		mg/m^3			mg/m^3
silver		mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	6.4E–13	mg/m^3			mg/m^3
uranium–total	4.8E–09	mg/m^3			mg/m^3
		mg/m^3			

Targets

000346

6346

Table H.IV–26 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	NA	NA
aroclor–1254	9.1E–12	NA	NA
aroclor–1260	NA	NA	NA
arsenic	3.0E–11	NA	NA
beryllium	4.7E–12	NA	NA
benzo(a)pyrene	7.2E–12	NA	NA
cadmium	5.3E–12	NA	NA
1,2–dichloroethane	NA	2.9E–03	NA
magnesium	3.0E–07	NA	NA
manganese	NA	1.4E–05	NA
mercury	NA	8.6E–05	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	4.9E–13	NA	NA
uranium–total	3.6E–09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	7.8E–13	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.6E–12	1.5E+01	3.9E–11
beryllium	4.0E–13	8.4E+00	3.4E–12
benzo(a)pyrene	6.1E–13	6.1E+00	3.7E–12
cadmium	4.6E–13	6.3E+00	2.9E–12
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	2.6E–08	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	4.2E–14	6.0E–03	2.5E–16
uranium–total	3.1E–10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.9E–11

000247

Table H.IV-27
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Child)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Ca	Concentration of radionuclides in air	(see table below)

Ra_{226+8d}	6.2E-08	pCi/m^3	pCi/m^3
Rn_{222}	8.0E-01	pCi/m^3	pCi/m^3
Sr_{90+1d}	2.4E-08	pCi/m^3	pCi/m^3
Tc_{99}	3.3E-07	pCi/m^3	pCi/m^3
Th_{230}	2.4E-07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	1.7E-09	pCi/m^3	pCi/m^3
$U_{235/236}$	5.0E-09	pCi/m^3	pCi/m^3
U_{238+2d}	1.6E-06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E-03	7.0E-09	1.1E-11
Rn_{222}	2.0E+04	7.3E-13	1.5E-08
Sr_{90+1d}	6.1E-04	6.2E-11	3.8E-14
Tc_{99}	8.4E-03	8.3E-12	7.0E-14
Th_{230}	6.1E-03	2.9E-08	1.8E-10
$Th_{232+10d}$	4.4E-05	1.1E-07	4.8E-12
$U_{235/236}$	1.2E-04	2.5E-08	3.1E-12
U_{238+2d}	4.0E-02	2.4E-08	9.6E-10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.6E-08

Table H.IV-28
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	200	mg/day
CF	Conversion factor	1.0E-06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for nOff-carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190	days
CS	Concentration of chemicals in soil	(see table below)	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/kg			mg/kg
arodor-1254	2.2E-02	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic		mg/kg			mg/kg
beryllium		mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium		mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	2.6E+02	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	2.0E-03	mg/kg			mg/kg
uranium-total	3.9E+00	mg/kg			mg/kg
		mg/kg			

Targets

Table H.IV-28 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	
aroclor-1254	2.8E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.0E-04	
beryllium	NA	5.0E-03	
benzo(a)pyrene	2.6E-07	NA	NA
cadmium	NA	1.0E-03	
1,2-dichloroethane	NA	NA	NA
magnesium	3.4E-03	9.7E+00	3.5E-04
manganese	NA	1.4E-01	
mercury	NA	3.0E-04	
silver	NA	5.0E-03	
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.6E-08	6.0E-03	4.3E-06
uranium-total	5.0E-05	3.0E-03	1.7E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.7E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	2.4E-08	7.7E+00	1.9E-07
aroclor-1260	NA	7.7E+00	
arsenic	NA	1.8E+00	
beryllium	NA	4.3E+00	
benzo(a)pyrene	2.2E-08	7.3E+00	1.6E-07
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	2.9E-04	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	2.2E-09	1.1E-02	2.4E-11
uranium-total	4.3E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.5E-07

000350

Table H.IV-29
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	6 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}		pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.50E-05	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	2.65E-04	pCi/mg	pCi/mg
$Th_{232+10d}$		pCi/mg	pCi/mg
$U_{235/236}$	2.19E-05	pCi/mg	pCi/mg
U_{238+2d}	1.32E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	7.80E-10	NA
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	6.30E+00	3.60E-11	2.27E-10
Tc_{99}	1.05E+02	1.30E-12	1.37E-10
Th_{230}	1.11E+02	1.30E-11	1.45E-09
$Th_{232+10d}$	NA	1.70E-10	NA
$U_{235/236}$	9.20E+00	1.60E-11	1.47E-10
U_{238+2d}	5.54E+02	2.00E-11	1.11E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.30E-08

Table H.IV–30
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	2000 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E–02		mg/kg		NA	mg/kg
arodor–1254	6.00E–02	2.20E–02	mg/kg		NA	mg/kg
arodor–1260	6.00E–02		mg/kg		NA	mg/kg
arsenic	1.00E–03		mg/kg		NA	mg/kg
beryllium	1.00E–02		mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E–01	2.00E–02	mg/kg		NA	mg/kg
cadmium	1.00E–02		mg/kg		NA	mg/kg
1,2–dichloroethane	3.00E–01		mg/kg		NA	mg/kg
magnesium	1.00E–02	2.63E+02	mg/kg		NA	mg/kg
manganese	1.00E–02		mg/kg		NA	mg/kg
mercury	5.00E–02		mg/kg		NA	mg/kg
silver	1.00E–02		mg/kg		NA	mg/kg
2,3,7,8–tcdd	3.00E–02		mg/kg		NA	mg/kg
trichloroethene	3.00E–01	2.00E–03	mg/kg		NA	mg/kg
uranium–total	1.00E–02	3.93E+00	mg/kg		NA	mg/kg
	NA		mg/kg			

Targets

000352
6349

Table H.IV-30 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Dermal Contact with Soil

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	6.00E-05	
aroclor-1254	1.69E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	2.85E-04	
beryllium	NA	5.00E-03	
benzo(a)pyrene	7.67E-07	NA	NA
cadmium	NA	5.00E-05	
1,2-dichloroethane	NA	NA	NA
magnesium	3.36E-04	4.85E-01	6.93E-04
manganese	NA	4.20E-03	
mercury	NA	4.50E-05	
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.67E-08	5.88E-03	1.30E-05
uranium-total	5.02E-06	1.50E-04	3.35E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.42E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	1.45E-08	1.03E+01	1.49E-07
aroclor-1260	NA	1.03E+01	
arsenic	NA	1.84E+00	
beryllium	NA	4.30E+00	
benzo(a)pyrene	6.58E-08	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	2.88E-05	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	6.58E-09	1.12E-02	7.38E-11
uranium-total	4.31E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.49E-07

000353

Table H.IV–31
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor–1254		mg/l			mg/l
arodor–1260		mg/l			mg/l
arsenic		mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2–dichloroethane		mg/l			mg/l
magnesium		mg/l			mg/l
manganese		mg/l			mg/l
mercury		mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8–tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium–total	5.20E–03	mg/l			mg/l
		mg/l			

Targets

000354

Table H.IV-31 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.00E-04	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.00E-04	NA
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	NA
manganese	NA	5.00E-03	NA
mercury	NA	3.00E-04	NA
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	3.32E-04	3.00E-03	1.11E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.11E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	NA	1.75E+00	NA
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	2.85E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		

Table H.IV–32
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional Intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}		pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	5.4E–06	pCi/l	pCi/l
Tc_{99}	4.2E–01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	8.3E–02	pCi/l	pCi/l
U_{238+2d}	1.9E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	7.8E–10	NA
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.1E–02	3.6E–11	4.1E–13
Tc_{99}	8.8E+02	1.3E–12	1.1E–09
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	1.7E+02	1.6E–11	2.8E–09
U_{238+2d}	3.9E+03	2.0E–11	7.9E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		8.2E–08

Table H.IV-33
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2-day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for nOff-carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units
antimony	NA	mg/cm^2-day
arodor-1254	NA	mg/cm^2-day
arodor-1260	NA	mg/cm^2-day
arsenic	NA	mg/cm^2-day
beryllium	NA	mg/cm^2-day
benzo(a)pyrene	NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day
1,2-dichloroethane	NA	mg/cm^2-day
magnesium	NA	mg/cm^2-day
manganese	NA	mg/cm^2-day
mercury	NA	mg/cm^2-day
silver	NA	mg/cm^2-day
2,3,7,8-tcdd	NA	mg/cm^2-day
trichloroethene	NA	mg/cm^2-day
uranium-total	1.30E-08	mg/cm^2-day
	NA	mg/cm^2-day

Compound	DA	Units
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day
	NA	mg/cm^2-day

Targets

000357

Table H.IV-33 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	6.00E-05	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	2.85E-04	NA
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	4.85E-01	NA
manganese	NA	4.20E-03	NA
mercury	NA	4.50E-05	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	1.91E-05	1.50E-04	1.27E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.27E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	NA	1.84E+00	NA
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	1.64E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		

Table H.IV-34
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039	kg/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for nOff-carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190	days
CS	Concentration of chemicals in meat		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/kg			mg/kg
arodor-1254	6.7E-07	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	2.8E-11	mg/kg			mg/kg
beryllium	1.4E-12	mg/kg			mg/kg
benzo(a)pyrene	6.8E-07	mg/kg			mg/kg
cadmium	2.6E-11	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	6.6E-02	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	1.0E-09	mg/kg			mg/kg
uranium-total	7.8E-07	mg/kg			mg/kg
		mg/kg			

Targets

Table H.IV–34 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	4.0E–04	NA
aroclor–1254	1.3E–09	NA	NA
aroclor–1260	NA	NA	NA
arsenic	5.2E–14	3.0E–04	1.7E–10
beryllium	2.6E–15	5.0E–03	5.3E–13
benzo(a)pyrene	1.3E–09	NA	NA
cadmium	4.8E–14	1.0E–03	4.8E–11
1,2–dichloroethane	NA	NA	NA
magnesium	1.2E–04	9.7E+00	1.3E–05
manganese	NA	1.4E–01	NA
mercury	NA	3.0E–04	NA
silver	NA	5.0E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.9E–12	6.0E–03	3.1E–10
uranium–total	1.5E–09	3.0E–03	4.9E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.3E–05

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	1.1E–10	7.7E+00	8.3E–10
aroclor–1260	NA	7.7E+00	NA
arsenic	4.4E–15	1.8E+00	7.8E–15
beryllium	2.3E–16	4.3E+00	9.7E–16
benzo(a)pyrene	1.1E–10	7.3E+00	7.9E–10
cadmium	4.1E–15	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	1.1E–05	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.6E–13	1.1E–02	1.8E–15
uranium–total	1.2E–10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.6E–09

000360

6349

Table H.IV–35
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	3.8E–09	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	5.6E–04	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	8.6E–07	pCi/kg	pCi/kg
$Th_{232+10d}$	9.5E–13	pCi/kg	pCi/kg
$U_{235/236}$	4.9E–06	pCi/kg	pCi/kg
U_{238+2d}	2.6E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.3E–07	7.8E–10	1.8E–16
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	3.5E–02	3.6E–11	1.2E–12
Tc_{99}	6.2E+01	1.3E–12	8.1E–11
Th_{230}	5.3E–05	1.3E–11	6.9E–16
$Th_{232+10d}$	5.8E–11	1.7E–10	9.9E–21
$U_{235/236}$	3.0E–04	1.6E–11	4.8E–15
U_{238+2d}	1.6E–02	2.0E–11	3.2E–13
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		8.2E–11

Table H.IV–36
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/kg			mg/kg
arodor–1254	2.1E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	8.3E–10	mg/kg			mg/kg
beryllium	1.3E–12	mg/kg			mg/kg
benzo(a)pyrene	2.2E–04	mg/kg			mg/kg
cadmium	4.7E–08	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	5.3E+01	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.2E–07	mg/kg			mg/kg
uranium–total	2.4E–03	mg/kg			mg/kg
		mg/kg			

Targets

29000

6349

Table H.IV-36 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
aroclor-1254	9.1E-06	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.6E-11	3.0E-04	1.2E-07
beryllium	5.5E-14	5.0E-03	1.1E-11
benzo(a)pyrene	9.3E-06	NA	NA
cadmium	2.0E-09	1.0E-03	2.0E-06
1,2-dichloroethane	NA	NA	NA
magnesium	2.3E+00	9.7E+00	2.4E-01
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.4E-08	6.0E-03	2.3E-06
uranium-total	1.0E-04	3.0E-03	3.4E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.7E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	7.8E-07	7.7E+00	6.0E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	3.1E-12	1.8E+00	5.4E-12
beryllium	4.7E-15	4.3E+00	2.0E-14
benzo(a)pyrene	8.0E-07	7.3E+00	5.8E-06
cadmium	1.7E-10	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	2.0E-01	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.2E-09	1.1E-02	1.3E-11
uranium-total	8.8E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.2E-05

000363

Table H.IV–37
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	6.8E–06	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.8E+00	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	7.2E–04	pCi/kg	pCi/kg
$Th_{232+10d}$	7.9E–10	pCi/kg	pCi/kg
$U_{235/236}$	1.5E–02	pCi/kg	pCi/kg
U_{238+2d}	8.0E–01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	9.6E–03	7.8E–10	7.5E–12
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	4.0E+03	3.6E–11	1.4E–07
Tc_{99}	1.7E+06	1.3E–12	2.2E–06
Th_{230}	1.0E+00	1.3E–11	1.3E–11
$Th_{232+10d}$	1.1E–06	1.7E–10	1.9E–16
$U_{235/236}$	2.1E+01	1.6E–11	3.4E–10
U_{238+2d}	1.1E+03	2.0E–11	2.3E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.4E–06

Table H.IV–38
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/kg			mg/kg
arodor–1254	2.8E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	2.6E–07	mg/kg			mg/kg
beryllium	2.5E–08	mg/kg			mg/kg
benzo(a)pyrene	2.3E–04	mg/kg			mg/kg
cadmium	9.3E–07	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.6E+02	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.2E–03	mg/kg			mg/kg
uranium–total	5.9E–02	mg/kg			mg/kg
		mg/kg			

Targets

000365

Table H.IV-38 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.0E-04	NA
aroclor-1254	9.5E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.7E-10	3.0E-04	2.9E-06
beryllium	8.5E-11	5.0E-03	1.7E-08
benzo(a)pyrene	7.8E-07	NA	NA
cadmium	3.2E-09	1.0E-03	3.2E-06
1,2-dichloroethane	NA	NA	NA
magnesium	8.9E-01	9.7E+00	9.2E-02
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.1E-05	6.0E-03	1.8E-03
uranium-total	2.0E-04	3.0E-03	6.6E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.6E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	8.1E-08	7.7E+00	6.2E-07
aroclor-1260	NA	7.7E+00	NA
arsenic	7.4E-11	1.8E+00	1.3E-10
beryllium	7.3E-12	4.3E+00	3.1E-11
benzo(a)pyrene	6.7E-08	7.3E+00	4.9E-07
cadmium	2.7E-10	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	7.6E-02	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	9.2E-07	1.1E-02	1.0E-08
uranium-total	1.7E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.1E-06

Table H.IV–39
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	2.7E−04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	3.7E+01	pCi/kg	pCi/kg
Tc_{99}	2.4E+03.	pCi/kg	pCi/kg
Th_{230}	2.3E−01	pCi/kg	pCi/kg
$Th_{232+10d}$	2.2E−06	pCi/kg	pCi/kg
$U_{235/236}$	5.9E−01	pCi/kg	pCi/kg
U_{238+2d}	2.0E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.0E−02	7.8E−10	2.3E−11
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	4.2E+03	3.6E−11	1.5E−07
Tc_{99}	2.6E+05	1.3E−12	3.4E−07
Th_{230}	2.5E+01	1.3E−11	3.3E−10
$Th_{232+10d}$	2.5E−04	1.7E−10	4.2E−14
$U_{235/236}$	6.6E+01	1.6E−11	1.1E−09
U_{238+2d}	2.3E+03	2.0E−11	4.5E−08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		5.4E−07

Table H.IV–40
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	6 Year
ET_i	Fraction of day spent indoors	0.92 (unitless)
ET_o	Fraction of day spent outdoors	0.08 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	NA	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.50E–02	pCi/g	NA	pCi/g
Tc_{99}	2.50E–01	pCi/g	NA	pCi/g
Th_{230}	2.65E–01	pCi/g	NA	pCi/g
$Th_{232+10d}$	NA	pCi/g	NA	pCi/g
$U_{235/236}$	2.19E–02	pCi/g	NA	pCi/g
U_{238+2d}	1.32E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	6.0E–06	NA
Rn_{222}	NA	1.2E–09	NA
Sr_{90+1d}	4.7E–02	NA	
Tc_{99}	7.8E–01	6.0E–13	4.7E–13
Th_{230}	8.2E–01	5.4E–11	4.5E–11
$Th_{232+10d}$	NA	8.5E–06	NA
$U_{235/236}$	6.8E–02	2.4E–07	1.6E–08
U_{238+2d}	4.1E+00	5.1E–08	2.1E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.3E–07

Table H.IV.1-41
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations :

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.6E-10	mg/m^3			mg/m^3
arodor-1254	5.3E-11	mg/m^3			mg/m^3
arodor-1260		mg/m^3			mg/m^3
arsenic	3.1E-10	mg/m^3			mg/m^3
beryllium	7.3E-11	mg/m^3			mg/m^3
benzo(a)pyrene	1.3E-11	mg/m^3			mg/m^3
cadmium	5.9E-11	mg/m^3			mg/m^3
1,2-dichloroethane		mg/m^3			mg/m^3
magnesium	4.5E-06	mg/m^3			mg/m^3
manganese	2.0E-09	mg/m^3			mg/m^3
mercury		mg/m^3			mg/m^3
silver		mg/m^3			mg/m^3
2,3,7,8-tcdd		mg/m^3			mg/m^3
trichloroethene	7.7E-13	mg/m^3			mg/m^3
uranium-total	9.5E-09	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.IV.1-41 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.3E-10	NA	NA
aroclor-1254	1.4E-11	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.5E-11	NA	NA
beryllium	2.0E-11	NA	NA
benzo(a)pyrene	3.5E-12	NA	NA
cadmium	1.6E-11	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	1.2E-06	NA	NA
manganese	5.5E-10	1.4E-05	3.8E-05
mercury	NA	8.6E-05	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.1E-13	NA	NA
uranium-total	2.6E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		3.8E-05

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.3E-10	NA	NA
aroclor-1254	1.4E-11	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.5E-11	1.5E+01	1.3E-09
beryllium	2.0E-11	8.4E+00	1.7E-10
benzo(a)pyrene	3.5E-12	6.1E+00	2.1E-11
cadmium	1.6E-11	6.3E+00	1.0E-10
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.2E-06	NA	NA
manganese	5.5E-10	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.1E-13	6.0E-03	1.3E-15
uranium-total	2.6E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.6E-09

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Table H.IV–42
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)			20 m^3/day
EF	Exposure frequency			350 days/year
EDn	Exposure duration			70 Year
Ca	Concentration of radionuclides in air			(see table below)
	Ra_{226+8d}	7.9E–07	pCi/m^3	pCi/m^3
	Rn_{222}	1.1E+01	pCi/m^3	pCi/m^3
	Sr_{90+1d}	7.9E–08	pCi/m^3	pCi/m^3
	Tc_{99}	1.6E–07	pCi/m^3	pCi/m^3
	Th_{230}	8.4E–07	pCi/m^3	pCi/m^3
	$Th_{232+10d}$	8.0E–09	pCi/m^3	pCi/m^3
	$U_{235/236}$		pCi/m^3	pCi/m^3
	U_{238+2d}	3.2E–06	pCi/m^3	pCi/m^3
			pCi/m^3	pCi/m^3
			pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.9E–01	7.0E–09	2.7E–09
Rn_{222}	5.2E+06	7.3E–13	3.8E–06
Sr_{90+1d}	3.9E–02	6.2E–11	2.4E–12
Tc_{99}	7.8E–02	8.3E–12	6.5E–13
Th_{230}	4.1E–01	2.9E–08	1.2E–08
$Th_{232+10d}$	3.9E–03	1.1E–07	4.3E–10
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	1.6E+00	2.4E–08	3.7E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		3.9E–06

Table H.IV – 43
Summary of Risk Quantitation (chemicals)
Reference Receptor: On – Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.2E–01	mg/kg			mg/kg
arodor–1254	2.5E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	1.9E–01	mg/kg			mg/kg
beryllium	6.2E–02	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	7.6E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.8E+03	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	8.3E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-43 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.0E-07	4.0E-04	2.0E-03
aroclor-1254	6.1E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	4.7E-07	3.0E-04	1.6E-03
beryllium	1.5E-07	5.0E-03	3.0E-05
benzo(a)pyrene	4.9E-08	NA	NA
cadmium	1.9E-07	1.0E-03	1.9E-04
1,2-dichloroethane	NA	NA	NA
magnesium	7.0E-03	9.7E+00	7.2E-04
manganese	NA	1.4E-01	
mercury	NA	3.0E-04	
silver	NA	5.0E-03	
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.9E-09	6.0E-03	3.1E-07
uranium-total	2.0E-05	3.0E-03	6.8E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.1E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	8.0E-07	NA	NA
aroclor-1254	6.1E-08	7.7E+00	4.7E-07
aroclor-1260	NA	7.7E+00	
arsenic	4.7E-07	1.8E+00	8.3E-07
beryllium	1.5E-07	4.3E+00	6.6E-07
benzo(a)pyrene	4.9E-08	7.3E+00	3.6E-07
cadmium	1.9E-07	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	7.0E-03	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	1.9E-09	1.1E-02	2.0E-11
uranium-total	2.0E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.3E-06

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Table H.IV-44
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	70 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	3.84E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.19E-04	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	6.45E-04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.17E-05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.77E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.69E+03	7.80E-10	1.32E-06
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	5.25E+02	3.60E-11	1.89E-08
Tc_{99}	1.10E+03	1.30E-12	1.43E-09
Th_{230}	2.84E+03	1.30E-11	3.70E-08
$Th_{232+10d}$	1.40E+02	1.70E-10	2.38E-08
$U_{235/236}$	NA	1.60E-11	NA
U_{238+2d}	1.22E+04	2.00E-11	2.44E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.65E-06

Table H.IV–45
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E–02	3.23E–01	mg/kg		NA	mg/kg
arodor–1254	6.00E–02	2.46E–02	mg/kg		NA	mg/kg
arodor–1260	6.00E–02		mg/kg		NA	mg/kg
arsenic	1.00E–03	1.92E–01	mg/kg		NA	mg/kg
beryllium	1.00E–02	6.18E–02	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E–01	2.00E–02	mg/kg		NA	mg/kg
cadmium	1.00E–02	7.59E–02	mg/kg		NA	mg/kg
1,2–dichloroethane	3.00E–01		mg/kg		NA	mg/kg
magnesium	1.00E–02	2.82E+03	mg/kg		NA	mg/kg
manganese	1.00E–02		mg/kg		NA	mg/kg
mercury	5.00E–02		mg/kg		NA	mg/kg
silver	1.00E–02		mg/kg		NA	mg/kg
2,3,7,8–tcdd	3.00E–02		mg/kg		NA	mg/kg
trichloroethene	3.00E–01	7.55E–04	mg/kg		NA	mg/kg
uranium–total	1.00E–02	8.30E+00	mg/kg		NA	mg/kg
	NA		mg/kg			

References

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Table H.IV–45 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	2.54E–07	6.00E–05	4.24E–03
aroclor–1254	1.16E–07	NA	NA
aroclor–1260	NA	NA	NA
arsenic	1.51E–08	2.85E–04	5.31E–05
beryllium	4.87E–08	5.00E–03	9.74E–06
benzo(a)pyrene	4.73E–07	NA	NA
cadmium	5.98E–08	5.00E–05	1.20E–03
1,2–dichloroethane	NA	NA	NA
magnesium	2.22E–03	4.85E–01	4.58E–03
manganese	NA	4.20E–03	
mercury	NA	4.50E–05	
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.78E–08	5.88E–03	3.03E–06
uranium–total	6.54E–06	1.50E–04	4.36E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.37E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	2.54E–07	NA	NA
aroclor–1254	1.16E–07	1.03E+01	1.19E–06
aroclor–1260	NA	1.03E+01	
arsenic	1.51E–08	1.84E+00	2.79E–08
beryllium	4.87E–08	4.30E+00	2.09E–07
benzo(a)pyrene	4.73E–07	NA	NA
cadmium	5.98E–08	NA	NA
1,2–dichloroethane	NA	1.01E–01	
magnesium	2.22E–03	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	
trichloroethene	1.78E–08	1.12E–02	2.00E–10
uranium–total	6.54E–06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.43E–06

Table II.IV – 46
Summary of Risk Quantitation (chemicals)
Reference Receptor: On – Property Farm Resident (Adult)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non – carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non – carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor – 1254		mg/l			mg/l
arodor – 1260		mg/l			mg/l
arsenic		mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2 – dichloroethane		mg/l			mg/l
magnesium		mg/l			mg/l
manganese	1.42E – 02	mg/l			mg/l
mercury		mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8 – tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium – total	8.61E – 03	mg/l			mg/l
		mg/l			

References

Table H.IV–46 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	4.00E–04	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	NA	3.00E–04	NA
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E–03	NA
1,2–dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	NA
manganese	3.89E–04	5.00E–03	7.78E–02
mercury	NA	3.00E–04	NA
silver	NA	5.00E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	6.00E–03	NA
uranium–total	2.36E–04	3.00E–03	7.86E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			1.56E–01

Compound	ILCR Calculation CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	7.70E+00	NA
aroclor–1260	NA	7.70E+00	NA
arsenic	NA	1.75E+00	NA
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	9.10E–02	NA
magnesium	NA	NA	NA
manganese	3.89E–04	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E–02	NA
uranium–total	2.36E–04	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			

000278
6349

Table H.IV–47
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}	3.3E–10	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	2.8E–02	pCi/l	pCi/l
Tc_{99}	1.7E+01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	1.3E–01	pCi/l	pCi/l
U_{238+2d}	3.0E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E–05	7.8E–10	1.3E–14
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.4E+03	3.6E–11	5.0E–08
Tc_{99}	8.2E+05	1.3E–12	1.1E–06
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	6.5E+03	1.6E–11	1.0E–07
U_{238+2d}	1.5E+05	2.0E–11	2.9E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		4.2E–06

Table H.IV – 48
Summary of Risk Quantitation (chemicals)
Reference Receptor: On – Property Farm Resident (Adult)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2-day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	25550	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1254	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1260	NA	mg/cm^2-day		NA	mg/cm^2-day
arsenic	NA	mg/cm^2-day		NA	mg/cm^2-day
beryllium	NA	mg/cm^2-day		NA	mg/cm^2-day
benzo(a)pyrene	NA	mg/cm^2-day		NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day		NA	mg/cm^2-day
1,2-dichloroethane	NA	mg/cm^2-day		NA	mg/cm^2-day
magnesium	NA	mg/cm^2-day		NA	mg/cm^2-day
manganese	3.55E-08	mg/cm^2-day		NA	mg/cm^2-day
mercury	NA	mg/cm^2-day		NA	mg/cm^2-day
silver	NA	mg/cm^2-day		NA	mg/cm^2-day
2,3,7,8-tcdd	NA	mg/cm^2-day		NA	mg/cm^2-day
trichloroethene	NA	mg/cm^2-day		NA	mg/cm^2-day
uranium-total	2.15E-08	mg/cm^2-day		NA	mg/cm^2-day
	NA	mg/cm^2-day			

References

000230

Table H.IV–48 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	6.00E–05	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	NA	2.85E–04	NA
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E–05	NA
1,2–dichloroethane	NA	NA	NA
magnesium	NA	4.85E–01	NA
manganese	1.12E–05	4.20E–03	2.66E–03
mercury	NA	4.50E–05	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	5.88E–03	NA
uranium–total	6.78E–06	1.50E–04	4.52E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.79E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
arsenic	NA	1.84E+00	NA
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	1.01E–01	NA
magnesium	NA	NA	NA
manganese	1.12E–05	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E–02	NA
uranium–total	6.78E–06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		

Table H.IV–49
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.4E–06	mg/kg			mg/kg
arodor–1254	7.5E–07	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	9.6E–07	mg/kg			mg/kg
beryllium	6.2E–08	mg/kg			mg/kg
benzo(a)pyrene	6.8E–07	mg/kg			mg/kg
cadmium	1.2E–06	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	7.1E–01	mg/kg			mg/kg
manganese	2.9E–07	mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.8E–10	mg/kg			mg/kg
uranium–total	1.6E–06	mg/kg			mg/kg
		mg/kg			

References

000782

Table H.IV-49 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.5E-09	4.0E-04	8.7E-06
aroclor-1254	7.7E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.9E-10	3.0E-04	3.3E-06
beryllium	6.4E-11	5.0E-03	1.3E-08
benzo(a)pyrene	7.0E-10	NA	NA
cadmium	1.2E-09	1.0E-03	1.2E-06
1,2-dichloroethane	NA	NA	NA
magnesium	7.3E-04	9.7E+00	7.5E-05
manganese	2.9E-10	1.4E-01	2.1E-09
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.9E-13	6.0E-03	6.5E-11
uranium-total	1.7E-09	3.0E-03	5.6E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		8.9E-05

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.5E-09	NA	NA
aroclor-1254	7.7E-10	7.7E+00	5.9E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	9.9E-10	1.8E+00	1.7E-09
beryllium	6.4E-11	4.3E+00	2.7E-10
benzo(a)pyrene	7.0E-10	7.3E+00	5.1E-09
cadmium	1.2E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	7.3E-04	NA	NA
manganese	2.9E-10	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.9E-13	1.1E-02	4.3E-15
uranium-total	1.7E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.3E-08

000383

Table H.IV–50
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	1.2E–04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	4.5E–03	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	2.1E–06	pCi/kg	pCi/kg
$Th_{232+10d}$	1.0E–07	pCi/kg	pCi/kg
$U_{235/236}$	1.3E–06	pCi/kg	pCi/kg
U_{238+2d}	5.4E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.2E–01	7.8E–10	1.7E–10
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	8.2E+00	3.6E–11	3.0E–10
Tc_{99}	1.9E+03	1.3E–12	2.4E–09
Th_{230}	3.9E–03	1.3E–11	5.0E–14
$Th_{232+10d}$	1.9E–04	1.7E–10	3.2E–14
$U_{235/236}$	2.4E–03	1.6E–11	3.9E–14
U_{238+2d}	1.0E+00	2.0E–11	2.0E–11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.9E–09

Table H.IV-51
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4	l/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in animal products		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.4E-04	mg/kg			mg/kg
arodor-1254	2.4E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	2.9E-05	mg/kg			mg/kg
beryllium	5.6E-08	mg/kg			mg/kg
benzo(a)pyrene	2.2E-04	mg/kg			mg/kg
cadmium	2.1E-03	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	5.7E+02	mg/kg			mg/kg
manganese	3.0E-04	mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	1.2E-07	mg/kg			mg/kg
uranium-total	4.9E-03	mg/kg			mg/kg
		mg/kg			

References

000285

Table H.IV-51 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.4E-06	4.0E-04	3.5E-03
aroclor-1254	9.7E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.2E-07	3.0E-04	3.9E-04
beryllium	2.3E-10	5.0E-03	4.6E-08
benzo(a)pyrene	8.8E-07	NA	NA
cadmium	8.7E-06	1.0E-03	8.7E-03
1,2-dichloroethane	NA	NA	NA
magnesium	2.3E+00	9.7E+00	2.4E-01
manganese	1.2E-06	1.4E-01	8.8E-06
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-10	6.0E-03	8.2E-08
uranium-total	2.0E-05	3.0E-03	6.7E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.6E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.4E-06	NA	NA
aroclor-1254	9.7E-07	7.7E+00	7.5E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	1.2E-07	1.8E+00	2.1E-07
beryllium	2.3E-10	4.3E+00	9.8E-10
benzo(a)pyrene	8.8E-07	7.3E+00	6.5E-06
cadmium	8.7E-06	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	2.3E+00	NA	NA
manganese	1.2E-06	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.9E-10	1.1E-02	5.4E-12
uranium-total	2.0E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.4E-05

000386

9349

Table H.IV–52
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	2.2E–01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.2E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	1.7E–03	pCi/kg	pCi/kg
$Th_{232+10d}$	8.6E–05	pCi/kg	pCi/kg
$U_{235/236}$	4.8E–03	pCi/kg	pCi/kg
U_{238+2d}	1.6E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E+03	7.8E–10	1.2E–06
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.6E+05	3.6E–11	5.9E–06
Tc_{99}	8.8E+06	1.3E–12	1.1E–05
Th_{230}	1.3E+01	1.3E–11	1.7E–10
$Th_{232+10d}$	6.3E–01	1.7E–10	1.1E–10
$U_{235/236}$	3.5E+01	1.6E–11	5.6E–10
U_{238+2d}	1.2E+04	2.0E–11	2.4E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation	=	1.9E–05

Table H.IV – 53
Summary of Risk Quantitation (chemicals)
Reference Receptor: On – Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122	kg/day
FI	Fraction ingested from contaminated source	0.5	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non – carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non – carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in vegetables		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	6.5E–02	mg/kg			mg/kg
arodor – 1254	3.1E–04	mg/kg			mg/kg
arodor – 1260		mg/kg			mg/kg
arsenic	7.7E–03	mg/kg			mg/kg
beryllium	6.2E–04	mg/kg			mg/kg
benzo(a)pyrene	2.3E–04	mg/kg			mg/kg
cadmium	4.2E–02	mg/kg			mg/kg
1,2 – dichloroethane		mg/kg			mg/kg
magnesium	2.8E+03	mg/kg			mg/kg
manganese	7.0E–02	mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8 – tcdd		mg/kg			mg/kg
trichloroethene	1.2E–03	mg/kg			mg/kg
uranium – total	1.1E–01	mg/kg			mg/kg
		mg/kg			

References

Table H.IV–53 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	5.4E–05	4.0E–04	1.3E–01
aroclor–1254	2.6E–07	NA	NA
aroclor–1260	NA	NA	NA
arsenic	6.4E–06	3.0E–04	2.1E–02
beryllium	5.2E–07	5.0E–03	1.0E–04
benzo(a)pyrene	1.9E–07	NA	NA
cadmium	3.5E–05	1.0E–03	3.5E–02
1,2–dichloroethane	NA	NA	NA
magnesium	2.4E+00	9.7E+00	2.4E–01
manganese	5.9E–05	1.4E–01	4.2E–04
mercury	NA	3.0E–04	NA
silver	NA	5.0E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.0E–06	6.0E–03	1.7E–04
uranium–total	9.4E–05	3.0E–03	3.1E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.7E–01

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	5.4E–05	NA	NA
aroclor–1254	2.6E–07	7.7E+00	2.0E–06
aroclor–1260	NA	7.7E+00	NA
arsenic	6.4E–06	1.8E+00	1.1E–05
beryllium	5.2E–07	4.3E+00	2.2E–06
benzo(a)pyrene	1.9E–07	7.3E+00	1.4E–06
cadmium	3.5E–05	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	2.4E+00	NA	NA
manganese	5.9E–05	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.0E–06	1.1E–02	1.1E–08
uranium–total	9.4E–05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.7E–05

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Table H.IV–54
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	5.8E+00	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	3.0E+02	pCi/kg	pCi/kg
Tc_{99}	2.5E+03	pCi/kg	pCi/kg
Th_{230}	5.5E−01	pCi/kg	pCi/kg
$Th_{232+10d}$	2.7E−02	pCi/kg	pCi/kg
$U_{235/236}$	6.5E−01	pCi/kg	pCi/kg
U_{238+2d}	3.8E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	8.6E+03	7.8E−10	6.7E−06
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	4.4E+05	3.6E−11	1.6E−05
Tc_{99}	3.7E+06	1.3E−12	4.8E−06
Th_{230}	8.2E+02	1.3E−11	1.1E−08
$Th_{232+10d}$	4.0E+01	1.7E−10	6.8E−09
$U_{235/236}$	9.7E+02	1.6E−11	1.6E−08
U_{238+2d}	5.7E+04	2.0E−11	1.1E−06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.9E−05

Table H.IV–55
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	70 Year
ET_i	Fraction of day spent indoors	0.76 (unitless)
ET_o	Fraction of day spent outdoors	0.24 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	3.84E–01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.19E–01	pCi/g	NA	pCi/g
Tc_{99}	2.50E–01	pCi/g	NA	pCi/g
Th_{230}	6.45E–01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.17E–02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.77E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E+01	6.0E–06	9.6E–05
Rn_{222}	NA	1.2E–09	NA
Sr_{90+1d}	5.0E+00	NA	
Tc_{99}	1.0E+01	6.0E–13	6.2E–12
Th_{230}	2.7E+01	5.4E–11	1.5E–09
$Th_{232+10d}$	1.3E+00	8.5E–06	1.1E–05
$U_{235/236}$	NA	2.4E–07	NA
U_{238+2d}	1.2E+02	5.1E–08	5.9E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.1E–04

Table H.IV–56
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.6E–10	mg/m^3			mg/m^3
arodor–1254	5.3E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	3.1E–10	mg/m^3			mg/m^3
beryllium	7.3E–11	mg/m^3			mg/m^3
benzo(a)pyrene	1.3E–11	mg/m^3			mg/m^3
cadmium	5.9E–11	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	4.5E–06	mg/m^3			mg/m^3
manganese	2.0E–09	mg/m^3			mg/m^3
mercury		mg/m^3			mg/m^3
silver		mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	7.7E–13	mg/m^3			mg/m^3
uranium–total	9.5E–09	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.IV–56 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	3.5E–10	NA	NA
aroclor–1254	4.0E–11	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.4E–10	NA	NA
beryllium	5.6E–11	NA	NA
benzo(a)pyrene	9.8E–12	NA	NA
cadmium	4.5E–11	NA	NA
1,2–dichloroethane	NA	2.9E–03	NA
magnesium	3.4E–06	NA	NA
manganese	1.5E–09	1.4E–05	1.1E–04
mercury	NA	8.6E–05	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	5.9E–13	NA	NA
uranium–total	7.3E–09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
Hazard Quotient Sum =			1.1E–04

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	3.0E–11	NA	NA
aroclor–1254	3.5E–12	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.0E–11	1.5E+01	3.1E–10
beryllium	4.8E–12	8.4E+00	4.0E–11
benzo(a)pyrene	8.4E–13	6.1E+00	5.1E–12
cadmium	3.9E–12	6.3E+00	2.4E–11
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	2.9E–07	NA	NA
manganese	1.3E–10	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	5.1E–14	6.0E–03	3.0E–16
uranium–total	6.3E–10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			3.8E–10

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Table H.IV–57
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		12 m^3/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		6 Year
Ca	Concentration of radionuclides in air		(see table below)

Ra_{226+8d}	7.9E–07	pCi/m^3	pCi/m^3
Rn_{222}	1.1E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	7.9E–08	pCi/m^3	pCi/m^3
Tc_{99}	1.6E–07	pCi/m^3	pCi/m^3
Th_{230}	8.4E–07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	8.0E–09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.2E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.0E–02	7.0E–09	1.4E–10
Rn_{222}	2.7E+05	7.3E–13	2.0E–07
Sr_{90+1d}	2.0E–03	6.2E–11	1.2E–13
Tc_{99}	4.0E–03	8.3E–12	3.3E–14
Th_{230}	2.1E–02	2.9E–08	6.2E–10
$Th_{232+10d}$	2.0E–04	1.1E–07	2.2E–11
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	8.0E–02	2.4E–08	1.9E–09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.0E–07

Table H.IV – 58
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.2E–01	mg/kg			mg/kg
arodor–1254	2.5E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	1.9E–01	mg/kg			mg/kg
beryllium	6.2E–02	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	7.6E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.8E+03	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	8.3E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-58 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.1E-06	4.0E-04	1.0E-02
aroclor-1254	3.1E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.5E-06	3.0E-04	8.2E-03
beryllium	7.9E-07	5.0E-03	1.6E-04
benzo(a)pyrene	2.6E-07	NA	NA
cadmium	9.7E-07	1.0E-03	9.7E-04
1,2-dichloroethane	NA	NA	NA
magnesium	3.6E-02	9.7E+00	3.7E-03
manganese	NA	1.4E-01	
mercury	NA	3.0E-04	
silver	NA	5.0E-03	
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	9.7E-09	6.0E-03	1.6E-06
uranium-total	1.1E-04	3.0E-03	3.5E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.9E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.5E-07	NA	NA
aroclor-1254	2.7E-08	7.7E+00	2.1E-07
aroclor-1260	NA	7.7E+00	
arsenic	2.1E-07	1.8E+00	3.7E-07
beryllium	6.8E-08	4.3E+00	2.9E-07
benzo(a)pyrene	2.2E-08	7.3E+00	1.6E-07
cadmium	8.3E-08	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	3.1E-03	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	8.3E-10	1.1E-02	9.1E-12
uranium-total	9.1E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.0E-06

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Table H.IV–59
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	6 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	3.84E–04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.19E–04	pCi/mg	pCi/mg
Tc_{99}	2.50E–04	pCi/mg	pCi/mg
Th_{230}	6.45E–04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.17E–05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.77E–03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.61E+02	7.80E–10	1.26E–07
Rn_{222}	NA	1.40E–12	NA
Sr_{90+1d}	5.00E+01	3.60E–11	1.80E–09
Tc_{99}	1.05E+02	1.30E–12	1.37E–10
Th_{230}	2.71E+02	1.30E–11	3.52E–09
$Th_{232+10d}$	1.33E+01	1.70E–10	2.26E–09
$U_{235/236}$	NA	1.60E–11	NA
U_{238+2d}	1.16E+03	2.00E–11	2.33E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.57E–07

Table H.IV–60
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	2000	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	2190	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E–02	3.23E–01	mg/kg	NA		mg/kg
arodor–1254	6.00E–02	2.46E–02	mg/kg	NA		mg/kg
arodor–1260	6.00E–02		mg/kg	NA		mg/kg
arsenic	1.00E–03	1.92E–01	mg/kg	NA		mg/kg
beryllium	1.00E–02	6.18E–02	mg/kg	NA		mg/kg
benzo(a)pyrene	3.00E–01	2.00E–02	mg/kg	NA		mg/kg
cadmium	1.00E–02	7.59E–02	mg/kg	NA		mg/kg
1,2–dichloroethane	3.00E–01		mg/kg	NA		mg/kg
magnesium	1.00E–02	2.82E+03	mg/kg	NA		mg/kg
manganese	1.00E–02		mg/kg	NA		mg/kg
mercury	5.00E–02		mg/kg	NA		mg/kg
silver	1.00E–02		mg/kg	NA		mg/kg
2,3,7,8–tcdd	3.00E–02		mg/kg	NA		mg/kg
trichloroethene	3.00E–01	7.55E–04	mg/kg	NA		mg/kg
uranium–total	1.00E–02	8.30E+00	mg/kg	NA		mg/kg
	NA		mg/kg			

References

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Table H.IV-60 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.13E-07	6.00E-05	6.88E-03
aroclor-1254	1.89E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.45E-08	2.85E-04	8.61E-05
beryllium	7.90E-08	5.00E-03	1.58E-05
benzo(a)pyrene	7.67E-07	NA	NA
cadmium	9.70E-08	5.00E-05	1.94E-03
1,2-dichloroethane	NA	NA	NA
magnesium	3.61E-03	4.85E-01	7.43E-03
manganese	NA	4.20E-03	
mercury	NA	4.50E-05	
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.90E-08	5.88E-03	4.92E-06
uranium-total	1.06E-05	1.50E-04	7.07E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		8.71E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.54E-08	NA	NA
aroclor-1254	1.62E-08	1.03E+01	1.66E-07
aroclor-1260	NA	1.03E+01	
arsenic	2.10E-09	1.84E+00	3.88E-09
beryllium	6.77E-09	4.30E+00	2.91E-08
benzo(a)pyrene	6.58E-08	NA	NA
cadmium	8.32E-09	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	3.09E-04	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	2.48E-09	1.12E-02	2.79E-11
uranium-total	9.10E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.99E-07

006399

Table H.IV–61
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units
antimony		mg/l
arodor–1254		mg/l
arodor–1260		mg/l
arsenic		mg/l
beryllium		mg/l
benzo(a)pyrene		mg/l
cadmium		mg/l
1,2–dichloroethane		mg/l
magnesium		mg/l
manganese	1.42E–02	mg/l
mercury		mg/l
silver		mg/l
2,3,7,8–tcdd		mg/l
trichloroethene		mg/l
uranium–total	8.61E–03	mg/l
		mg/l

Compound	Concentration	Units
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l

References

Table H.IV-61 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Drinking Water Ingestion

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.00E-04	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.00E-04	NA
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	NA
manganese	9.08E-04	5.00E-03	1.82E-01
mercury	NA	3.00E-04	NA
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	5.50E-04	3.00E-03	1.83E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.65E-01

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	NA	1.75E+00	NA
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	NA	NA	NA
manganese	7.78E-05	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	4.72E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		

000401

Table H.IV–62
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}	3.3E–10	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	2.8E–02	pCi/l	pCi/l
Tc_{99}	1.7E+01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	1.3E–01	pCi/l	pCi/l
U_{238+2d}	3.0E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.9E–07	7.8E–10	5.4E–16
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	5.9E+01	3.6E–11	2.1E–09
Tc_{99}	3.5E+04	1.3E–12	4.6E–08
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	2.8E+02	1.6E–11	4.5E–09
U_{238+2d}	6.3E+03	2.0E–11	1.3E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.8E–07

Table H.IV-63
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2-day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	2190	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1254	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1260	NA	mg/cm^2-day		NA	mg/cm^2-day
arsenic	NA	mg/cm^2-day		NA	mg/cm^2-day
beryllium	NA	mg/cm^2-day		NA	mg/cm^2-day
benzo(a)pyrene	NA	mg/cm^2-day		NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day		NA	mg/cm^2-day
1,2-dichloroethane	NA	mg/cm^2-day		NA	mg/cm^2-day
magnesium	NA	mg/cm^2-day		NA	mg/cm^2-day
manganese	3.55E-08	mg/cm^2-day		NA	mg/cm^2-day
mercury	NA	mg/cm^2-day		NA	mg/cm^2-day
silver	NA	mg/cm^2-day		NA	mg/cm^2-day
2,3,7,8-tcdd	NA	mg/cm^2-day		NA	mg/cm^2-day
trichloroethene	NA	mg/cm^2-day		NA	mg/cm^2-day
uranium-total	2.15E-08	mg/cm^2-day		NA	mg/cm^2-day
	NA	mg/cm^2-day			

References

Table H.IV-63 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	6.00E-05	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	2.85E-04	NA
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	4.85E-01	NA
manganese	5.22E-05	4.20E-03	1.24E-02
mercury	NA	4.50E-05	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	3.16E-05	1.50E-04	2.11E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.23E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	NA	1.84E+00	NA
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	NA	NA	NA
manganese	4.47E-06	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	2.71E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		

Table II.IV–64
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.4E–06	mg/kg			mg/kg
arodor–1254	7.5E–07	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	9.6E–07	mg/kg			mg/kg
beryllium	6.2E–08	mg/kg			mg/kg
benzo(a)pyrene	6.8E–07	mg/kg			mg/kg
cadmium	1.2E–06	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	7.1E–01	mg/kg			mg/kg
manganese	2.9E–07	mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.8E–10	mg/kg			mg/kg
uranium–total	1.6E–06	mg/kg			mg/kg
		mg/kg			

References

000405

Table H.IV-64 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	6.3E-09	4.0E-04	1.6E-05
aroclor-1254	1.4E-09	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.8E-09	3.0E-04	6.0E-06
beryllium	1.2E-10	5.0E-03	2.3E-08
benzo(a)pyrene	1.3E-09	NA	NA
cadmium	2.2E-09	1.0E-03	2.2E-06
1,2-dichloroethane	NA	NA	NA
magnesium	1.3E-03	9.7E+00	1.4E-04
manganese	5.3E-10	1.4E-01	3.8E-09
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.1E-13	6.0E-03	1.2E-10
uranium-total	3.0E-09	3.0E-03	1.0E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.6E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.4E-10	NA	NA
aroclor-1254	1.2E-10	7.7E+00	9.3E-10
aroclor-1260	NA	7.7E+00	NA
arsenic	1.5E-10	1.8E+00	2.7E-10
beryllium	9.9E-12	4.3E+00	4.3E-11
benzo(a)pyrene	1.1E-10	7.3E+00	7.9E-10
cadmium	1.9E-10	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.1E-04	NA	NA
manganese	4.6E-11	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	6.0E-14	1.1E-02	6.7E-16
uranium-total	2.6E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.0E-09

Table H.IV–65
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	1.2E–04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	4.5E–03	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	2.1E–06	pCi/kg	pCi/kg
$Th_{232+10d}$	1.0E–07	pCi/kg	pCi/kg
$U_{235/236}$	1.3E–06	pCi/kg	pCi/kg
U_{238+2d}	5.4E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	7.4E–03	7.8E–10	5.8E–12
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.7E–01	3.6E–11	9.9E–12
Tc_{99}	6.3E+01	1.3E–12	8.1E–11
Th_{230}	1.3E–04	1.3E–11	1.7E–15
$Th_{232+10d}$	6.3E–06	1.7E–10	1.1E–15
$U_{235/236}$	8.2E–05	1.6E–11	1.3E–15
U_{238+2d}	3.3E–02	2.0E–11	6.7E–13
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 9.8E–11

Table H.IV–66
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.4E–04	mg/kg			mg/kg
arodor–1254	2.4E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	2.9E–05	mg/kg			mg/kg
beryllium	5.6E–08	mg/kg			mg/kg
benzo(a)pyrene	2.2E–04	mg/kg			mg/kg
cadmium	2.1E–03	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	5.7E+02	mg/kg			mg/kg
manganese	3.0E–04	mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	1.2E–07	mg/kg			mg/kg
uranium–total	4.9E–03	mg/kg			mg/kg
		mg/kg			

References

000708

Table H.IV-66 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.5E-05	4.0E-04	3.7E-02
aroclor-1254	1.0E-05	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.2E-06	3.0E-04	4.1E-03
beryllium	2.4E-09	5.0E-03	4.8E-07
benzo(a)pyrene	9.3E-06	NA	NA
cadmium	9.2E-05	1.0E-03	9.2E-02
1,2-dichloroethane	NA	NA	NA
magnesium	2.5E+01	9.7E+00	2.5E+00
manganese	1.3E-05	1.4E-01	9.2E-05
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	5.2E-09	6.0E-03	8.6E-07
uranium-total	2.1E-04	3.0E-03	7.1E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.7E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.3E-06	NA	NA
aroclor-1254	8.8E-07	7.7E+00	6.8E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	1.1E-07	1.8E+00	1.9E-07
beryllium	2.1E-10	4.3E+00	8.8E-10
benzo(a)pyrene	8.0E-07	7.3E+00	5.8E-06
cadmium	7.9E-06	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	2.1E+00	NA	NA
manganese	1.1E-06	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.4E-10	1.1E-02	4.9E-12
uranium-total	1.8E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.3E-05

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Table H.IV–67
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	2.2E–01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.2E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	1.7E–03	pCi/kg	pCi/kg
$Th_{232+10d}$	8.6E–05	pCi/kg	pCi/kg
$U_{235/236}$	4.8E–03	pCi/kg	pCi/kg
U_{238+2d}	1.6E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.1E+02	7.8E–10	2.4E–07
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	3.2E+04	3.6E–11	1.1E–06
Tc_{99}	1.7E+06	1.3E–12	2.2E–06
Th_{230}	2.5E+00	1.3E–11	3.2E–11
$Th_{232+10d}$	1.2E–01	1.7E–10	2.1E–11
$U_{235/236}$	6.8E+00	1.6E–11	1.1E–10
U_{238+2d}	2.3E+03	2.0E–11	4.7E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		3.6E–06

Table II.IV–68
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	6.5E–02	mg/kg			mg/kg
arodor–1254	3.1E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	7.7E–03	mg/kg			mg/kg
beryllium	6.2E–04	mg/kg			mg/kg
benzo(a)pyrene	2.3E–04	mg/kg			mg/kg
cadmium	4.2E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.8E+03	mg/kg			mg/kg
manganese	7.0E–02	mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	1.2E–03	mg/kg			mg/kg
uranium–total	1.1E–01	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-68 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.2E-04	4.0E-04	5.5E-01
aroclor-1254	1.1E-06	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.6E-05	3.0E-04	8.7E-02
beryllium	2.1E-06	5.0E-03	4.2E-04
benzo(a)pyrene	7.8E-07	NA	NA
cadmium	1.4E-04	1.0E-03	1.4E-01
1,2-dichloroethane	NA	NA	NA
magnesium	9.6E+00	9.7E+00	9.9E-01
manganese	2.4E-04	1.4E-01	1.7E-03
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.1E-06	6.0E-03	6.8E-04
uranium-total	3.8E-04	3.0E-03	1.3E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.9E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.9E-05	NA	NA
aroclor-1254	9.1E-08	7.7E+00	7.0E-07
aroclor-1260	NA	7.7E+00	NA
arsenic	2.2E-06	1.8E+00	3.9E-06
beryllium	1.8E-07	4.3E+00	7.7E-07
benzo(a)pyrene	6.7E-08	7.3E+00	4.9E-07
cadmium	1.2E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	8.2E-01	NA	NA
manganese	2.0E-05	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.5E-07	1.1E-02	3.8E-09
uranium-total	3.3E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		5.9E-06

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Table H.IV–69
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables		0.106 kg/day
FI	Fraction ingested from contaminated source		0.5 (Unitless)
EF	Exposure frequency		350 days/year
EDn	Exposure duration		6 Year
Cv	Concentration of radionuclides in vegetables		

Ra_{226+8d}	5.8E+00	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	3.0E+02	pCi/kg	pCi/kg
Tc_{99}	2.5E+03	pCi/kg	pCi/kg
Th_{230}	5.5E–01	pCi/kg	pCi/kg
$Th_{232+10d}$	2.7E–02	pCi/kg	pCi/kg
$U_{235/236}$	6.5E–01	pCi/kg	pCi/kg
U_{238+2d}	3.8E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.4E+02	7.8E–10	5.0E–07
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	3.3E+04	3.6E–11	1.2E–06
Tc_{99}	2.8E+05	1.3E–12	3.6E–07
Th_{230}	6.1E+01	1.3E–11	7.9E–10
$Th_{232+10d}$	3.0E+00	1.7E–10	5.1E–10
$U_{235/236}$	7.2E+01	1.6E–11	1.2E–09
U_{238+2d}	4.3E+03	2.0E–11	8.5E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.1E–06

Table H.IV–70
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	6 Year
ET_i	Fraction of day spent indoors	0.92 (unitless)
ET_o	Fraction of day spent outdoors	0.08 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	3.84E–01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.19E–01	pCi/g	NA	pCi/g
Tc_{99}	2.50E–01	pCi/g	NA	pCi/g
Th_{230}	6.45E–01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.17E–02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.77E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.2E+00	6.0E–06	7.2E–06
Rn_{222}	NA	1.2E–09	NA
Sr_{90+1d}	3.7E–01	NA	
Tc_{99}	7.8E–01	6.0E–13	4.7E–13
Th_{230}	2.0E+00	5.4E–11	1.1E–10
$Th_{232+10d}$	9.9E–02	8.5E–06	8.4E–07
$U_{235/236}$	NA	2.4E–07	NA
U_{238+2d}	8.6E+00	5.1E–08	4.4E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		8.4E–06

Table H.IV – 71
Summary of risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Meat Products

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.4E-06	mg/kg			mg/kg
arodor-1254	7.5E-07	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	9.6E-07	mg/kg			mg/kg
beryllium	6.2E-08	mg/kg			mg/kg
benzo(a)pyrene	6.8E-07	mg/kg			mg/kg
cadmium	1.2E-06	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	7.1E-01	mg/kg			mg/kg
manganese	2.9E-07	mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.8E-10	mg/kg			mg/kg
uranium-total	1.6E-06	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-71 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.5E-09	4.0E-04	8.7E-06
aroclor-1254	7.7E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.9E-10	3.0E-04	3.3E-06
beryllium	6.4E-11	5.0E-03	1.3E-08
benzo(a)pyrene	7.0E-10	NA	NA
cadmium	1.2E-09	1.0E-03	1.2E-06
1,2-dichloroethane	NA	NA	NA
magnesium	7.3E-04	9.7E+00	7.5E-05
manganese	2.9E-10	1.4E-01	2.1E-09
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.9E-13	6.0E-03	6.5E-11
uranium-total	1.7E-09	3.0E-03	5.6E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		8.9E-05

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.5E-09	NA	NA
aroclor-1254	7.7E-10	7.7E+00	5.9E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	9.9E-10	1.8E+00	1.7E-09
beryllium	6.4E-11	4.3E+00	2.7E-10
benzo(a)pyrene	7.0E-10	7.3E+00	5.1E-09
cadmium	1.2E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	7.3E-04	NA	NA
manganese	2.9E-10	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.9E-13	1.1E-02	4.3E-15
uranium-total	1.7E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.3E-08

Table H.IV–72
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Meat Products

risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	1.2E−04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	4.5E−03	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	2.1E−06	pCi/kg	pCi/kg
$Th_{232+10d}$	1.0E−07	pCi/kg	pCi/kg
$U_{235/236}$	1.3E−06	pCi/kg	pCi/kg
U_{238+2d}	5.4E−04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.2E−01	7.8E−10	1.7E−10
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	8.2E+00	3.6E−11	3.0E−10
Tc_{99}	1.9E+03	1.3E−12	2.4E−09
Th_{230}	3.9E−03	1.3E−11	5.0E−14
$Th_{232+10d}$	1.9E−04	1.7E−10	3.2E−14
$U_{235/236}$	2.4E−03	1.6E−11	3.9E−14
U_{238+2d}	1.0E+00	2.0E−11	2.0E−11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.9E−09

Table H.IV – 73
Summary of risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Dairy Products

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.4E-04	mg/kg			mg/kg
arodor-1254	2.4E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	2.9E-05	mg/kg			mg/kg
beryllium	5.6E-08	mg/kg			mg/kg
benzo(a)pyrene	2.2E-04	mg/kg			mg/kg
cadmium	2.1E-03	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	5.7E+02	mg/kg			mg/kg
manganese	3.0E-04	mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	1.2E-07	mg/kg			mg/kg
uranium-total	4.9E-03	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-73 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.4E-06	4.0E-04	3.5E-03
aroclor-1254	9.7E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.2E-07	3.0E-04	3.9E-04
beryllium	2.3E-10	5.0E-03	4.6E-08
benzo(a)pyrene	8.8E-07	NA	NA
cadmium	8.7E-06	1.0E-03	8.7E-03
1,2-dichloroethane	NA	NA	NA
magnesium	2.3E+00	9.7E+00	2.4E-01
manganese	1.2E-06	1.4E-01	8.8E-06
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-10	6.0E-03	8.2E-08
uranium-total	2.0E-05	3.0E-03	6.7E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			2.6E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.4E-06	NA	NA
aroclor-1254	9.7E-07	7.7E+00	7.5E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	1.2E-07	1.8E+00	2.1E-07
beryllium	2.3E-10	4.3E+00	9.8E-10
benzo(a)pyrene	8.8E-07	7.3E+00	6.5E-06
cadmium	8.7E-06	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	2.3E+00	NA	NA
manganese	1.2E-06	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.9E-10	1.1E-02	5.4E-12
uranium-total	2.0E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			1.4E-05

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Table H.IV–74
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Dairy Products

risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	2.2E−01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.2E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	1.7E−03	pCi/kg	pCi/kg
$Th_{232+10d}$	8.6E−05	pCi/kg	pCi/kg
$U_{235/236}$	4.8E−03	pCi/kg	pCi/kg
U_{238+2d}	1.6E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E+03	7.8E−10	1.2E−06
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	1.6E+05	3.6E−11	5.9E−06
Tc_{99}	8.8E+06	1.3E−12	1.1E−05
Th_{230}	1.3E+01	1.3E−11	1.7E−10
$Th_{232+10d}$	6.3E−01	1.7E−10	1.1E−10
$U_{235/236}$	3.5E+01	1.6E−11	5.6E−10
U_{238+2d}	1.2E+04	2.0E−11	2.4E−07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.9E−05

Table H.IV – 75
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non-carcinogens	25 Year
EDc	Exposure duration for carcinogens	25 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/m^3			mg/m^3
arodor-1254	1.6E-11	mg/m^3			mg/m^3
arodor-1260		mg/m^3			mg/m^3
arsenic	9.0E-11	mg/m^3			mg/m^3
beryllium	1.4E-11	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E-11	mg/m^3			mg/m^3
cadmium	1.6E-11	mg/m^3			mg/m^3
1,2-dichloroethane		mg/m^3			mg/m^3
magnesium	7.7E-07	mg/m^3			mg/m^3
manganese		mg/m^3			mg/m^3
mercury		mg/m^3			mg/m^3
silver		mg/m^3			mg/m^3
2,3,7,8-tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E-13	mg/m^3			mg/m^3
uranium-total	8.9E-09	mg/m^3			mg/m^3
		mg/m^3			

References

000274

Table H.IV-75 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	NA	NA
aroclor-1254	3.1E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.8E-11	NA	NA
beryllium	2.7E-12	NA	NA
benzo(a)pyrene	2.2E-12	NA	NA
cadmium	3.1E-12	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	1.5E-07	NA	NA
manganese	NA	1.4E-05	NA
mercury	NA	8.6E-05	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	8.6E-14	NA	NA
uranium-total	1.7E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	1.1E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.3E-12	1.5E+01	9.4E-11
beryllium	9.8E-13	8.4E+00	8.2E-12
benzo(a)pyrene	7.8E-13	6.1E+00	4.7E-12
cadmium	1.1E-12	6.3E+00	7.0E-12
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	5.4E-08	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.1E-14	6.0E-03	1.9E-16
uranium-total	6.2E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.1E-10

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93469

Table H.IV–76
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Commercial/Industrial User
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		20 m^3/day
EF	Exposure frequency		250 days/year
EDn	Exposure duration		25 Year
Ca	Concentration of radionuclides in air		(see table below)

Ra_{226+8d}	1.4E−07	pCi/m^3	pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3	pCi/m^3
Sr_{90+1d}	4.8E−08	pCi/m^3	pCi/m^3
Tc_{99}	1.4E−07	pCi/m^3	pCi/m^3
Th_{230}	4.2E−07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	4.0E−09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.0E−06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.8E−02	7.0E−09	1.2E−10
Rn_{222}	2.3E+05	7.3E−13	1.7E−07
Sr_{90+1d}	6.0E−03	6.2E−11	3.7E−13
Tc_{99}	1.7E−02	8.3E−12	1.4E−13
Th_{230}	5.3E−02	2.9E−08	1.5E−09
$Th_{232+10d}$	5.0E−04	1.1E−07	5.5E−11
$U_{235/236}$	NA	2.5E−08	NA
U_{238+2d}	3.7E−01	2.4E−08	8.9E−09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.8E−07

Table H.IV – 77
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non–carcinogens	25 Year
EDc	Exposure duration for carcinogens	25 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.2E–01	mg/kg			mg/kg
arodor–1254	2.5E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	1.9E–01	mg/kg			mg/kg
beryllium	6.2E–02	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	7.6E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.8E+03	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	8.3E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-77 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.2E-07	4.0E-04	7.9E-04
aroclor-1254	2.4E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.9E-07	3.0E-04	6.3E-04
beryllium	6.0E-08	5.0E-03	1.2E-05
benzo(a)pyrene	2.0E-08	NA	NA
cadmium	7.4E-08	1.0E-03	7.4E-05
1,2-dichloroethane	NA	NA	NA
magnesium	2.8E-03	9.7E+00	2.8E-04
manganese	NA	1.4E-01	
mercury	NA	3.0E-04	
silver	NA	5.0E-03	
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.4E-10	6.0E-03	1.2E-07
uranium-total	8.1E-06	3.0E-03	2.7E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.5E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.1E-07	NA	
aroclor-1254	8.6E-09	7.7E+00	6.6E-08
aroclor-1260	NA	7.7E+00	NA
arsenic	6.7E-08	1.8E+00	1.2E-07
beryllium	2.2E-08	4.3E+00	9.3E-08
benzo(a)pyrene	7.0E-09	7.3E+00	5.1E-08
cadmium	2.7E-08	NA	
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	9.9E-04	NA	
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.6E-10	1.1E-02	2.9E-12
uranium-total	2.9E-06	NA	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.3E-07

000425

Table H.IV-78
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Commercial/Industrial User
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
EF	Exposure frequency	250 days/year
EDn	Exposure Duration	25 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	3.84E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.19E-04	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	6.45E-04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.17E-05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.77E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.40E+02	7.80E-10	1.87E-07
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	7.44E+01	3.60E-11	2.68E-09
Tc_{99}	1.56E+02	1.30E-12	2.03E-10
Th_{230}	4.03E+02	1.30E-11	5.24E-09
$Th_{232+10d}$	1.98E+01	1.70E-10	3.37E-09
$U_{235/236}$	NA	1.60E-11	NA
U_{238+2d}	1.73E+03	2.00E-11	3.46E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.33E-07

Table H.IV – 79
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E-06	kg/mg
EF	Exposure frequency	250	days/year
EDn	Exposure duration for non-carcinogens	25	Year
EDc	Exposure duration for carcinogens	25	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	9125	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E-02	3.23E-01	mg/kg	NA		mg/kg
arodor-1254	6.00E-02	2.46E-02	mg/kg	NA		mg/kg
arodor-1260	6.00E-02		mg/kg	NA		mg/kg
arsenic	1.00E-03	1.92E-01	mg/kg	NA		mg/kg
beryllium	1.00E-02	6.18E-02	mg/kg	NA		mg/kg
benzo(a)pyrene	3.00E-01	2.00E-02	mg/kg	NA		mg/kg
cadmium	1.00E-02	7.59E-02	mg/kg	NA		mg/kg
1,2-dichloroethane	3.00E-01		mg/kg	NA		mg/kg
magnesium	1.00E-02	2.82E+03	mg/kg	NA		mg/kg
manganese	1.00E-02		mg/kg	NA		mg/kg
mercury	5.00E-02		mg/kg	NA		mg/kg
silver	1.00E-02		mg/kg	NA		mg/kg
2,3,7,8-tcdd	3.00E-02		mg/kg	NA		mg/kg
trichloroethene	3.00E-01	7.55E-04	mg/kg	NA		mg/kg
uranium-total	1.00E-02	8.30E+00	mg/kg	NA		mg/kg
	NA		mg/kg			

References

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Table H.IV-79 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.82E-07	6.00E-05	3.03E-03
aroclor-1254	8.30E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.08E-08	2.85E-04	3.79E-05
beryllium	3.48E-08	5.00E-03	6.95E-06
benzo(a)pyrene	3.38E-07	NA	NA
cadmium	4.27E-08	5.00E-05	8.54E-04
1,2-dichloroethane	NA	NA	NA
magnesium	1.59E-03	4.85E-01	3.27E-03
manganese	NA	4.20E-03	
mercury	NA	4.50E-05	
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.27E-08	5.88E-03	2.17E-06
uranium-total	4.67E-06	1.50E-04	3.11E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.83E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.49E-08	NA	
aroclor-1254	2.97E-08	1.03E+01	3.04E-07
aroclor-1260	NA	1.03E+01	NA
arsenic	3.86E-09	1.84E+00	7.11E-09
beryllium	1.24E-08	4.30E+00	5.34E-08
benzo(a)pyrene	1.21E-07	NA	
cadmium	1.53E-08	NA	
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	5.67E-04	NA	
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	4.55E-09	1.12E-02	5.11E-11
uranium-total	1.67E-06	NA	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.65E-07

000628

6349

Table H.IV–80
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Commercial/Industrial User
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.68 (unitless)
ED	Exposure duration	25 Year
ET_i	Fraction of day spent indoors	0.8 (unitless)
ET_o	Fraction of day spent outdoors	0.2 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	3.84E−01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.19E−01	pCi/g	NA	pCi/g
Tc_{99}	2.50E−01	pCi/g	NA	pCi/g
Th_{230}	6.45E−01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.17E−02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.77E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.9E+00	6.0E−06	2.4E−05
Rn_{222}	NA	1.2E−09	NA
Sr_{90+1d}	1.2E+00	NA	
Tc_{99}	2.6E+00	6.0E−13	1.5E−12
Th_{230}	6.6E+00	5.4E−11	3.6E−10
$Th_{232+10d}$	3.2E−01	8.5E−06	2.7E−06
$U_{235/236}$	NA	2.4E−07	NA
U_{238+2d}	2.8E+01	5.1E−08	1.4E−06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.8E−05

Table H.IV – 81
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ET	Exposure time	4	4	4	2	hour/day
EF	Exposure frequency	64	104	40	40	days/year
ED	Exposure duration	6	12	38	14	years
BWa	Body weight (adult)	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	days
ATa	Average time for non-carcinogens (adult)	2190	4380	13870	5110	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units
antimony		mg/m^3
arodor-1254	1.6E-11	mg/m^3
arodor-1260		mg/m^3
arsenic	9.0E-11	mg/m^3
beryllium	1.4E-11	mg/m^3
benzo(a)pyrene	1.1E-11	mg/m^3
cadmium	1.6E-11	mg/m^3
1,2-dichloroethane		mg/m^3
magnesium	7.7E-07	mg/m^3
manganese		mg/m^3
mercury		mg/m^3
silver		mg/m^3
2,3,7,8-tcdd		mg/m^3
trichloroethene	4.4E-13	mg/m^3
uranium-total	8.9E-09	mg/m^3
		mg/m^3

Compound	Concentration	Units
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3

References

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Table H.IV-81 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	NA	NA
aroclor-1254	1.6E-13	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.4E-13	NA	NA
beryllium	1.5E-13	NA	NA
benzo(a)pyrene	1.2E-13	NA	NA
cadmium	1.7E-13	NA	NA
1,2-dichloroethane	NA	2.9E-03	
magnesium	8.0E-09	NA	NA
manganese	NA	1.4E-05	
mercury	NA	8.6E-05	
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.6E-15	NA	NA
uranium-total	9.3E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	1.6E-13	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.4E-13	1.5E+01	1.4E-11
beryllium	1.5E-13	8.4E+00	1.2E-12
benzo(a)pyrene	1.2E-13	6.1E+00	7.1E-13
cadmium	1.7E-13	6.3E+00	1.1E-12
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	8.0E-09	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.6E-15	6.0E-03	2.8E-17
uranium-total	9.3E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			1.7E-11

000434

Table H.IV–82
Summary of Intake and Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via Inhalation of Gases and Particulates

Intake Equation = CA X EF X ED X IR X ET

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ED	Exposure duration	6	12	38	14	years
ET	Exposure time	4	4	4	2	hour/day
EF	Exposure frequency	64	104	40	40	days/year
CA	Concentration of radionuclides in air	csv	csv	csv	csv	

Ra_{226+8d}	1.4E–07	pCi/m^3		pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3		pCi/m^3
Sr_{90+1d}	4.8E–08	pCi/m^3		pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3		pCi/m^3
Th_{230}	4.2E–07	pCi/m^3		pCi/m^3
$Th_{232+10d}$	4.0E–09	pCi/m^3		pCi/m^3
$U_{235/236}$		pCi/m^3		pCi/m^3
U_{238+2d}	3.0E–06	pCi/m^3		pCi/m^3
		pCi/m^3		pCi/m^3
		pCi/m^3		pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E–03	7.0E–09	1.1E–11
Rn_{222}	2.1E+04	7.3E–13	1.5E–08
Sr_{90+1d}	5.5E–04	6.2E–11	3.4E–14
Tc_{99}	1.6E–03	8.3E–12	1.3E–14
Th_{230}	4.8E–03	2.9E–08	1.4E–10
$Th_{232+10d}$	4.6E–05	1.1E–07	5.0E–12
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	3.4E–02	2.4E–08	8.1E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.6E–08

Table II.IV-83
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Incidental Ingestion of Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	50	25	25	13	mg/day
EF	Exposure frequency	64	104	40	40	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E-06	1E-06	1E-06	1E-06	kg/mg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non-carcinogens	2190	4380	13870	5110	day
BW	Body weight	15	43	70	70	kg
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.2E-01	mg/kg			mg/kg
aroclor-1254	2.5E-02	mg/kg			mg/kg
aroclor-1260		mg/kg			mg/kg
arsenic	1.9E-01	mg/kg			mg/kg
beryllium	6.2E-02	mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium	7.6E-02	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	2.8E+03	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	7.6E-04	mg/kg			mg/kg
uranium-total	8.3E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-83 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.4E-08	4.0E-04	8.4E-05
aroclor-1254	2.6E-09	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.0E-08	3.0E-04	6.6E-05
beryllium	6.4E-09	5.0E-03	1.3E-06
benzo(a)pyrene	2.1E-09	NA	NA
cadmium	7.9E-09	1.0E-03	7.9E-06
1,2-dichloroethane	NA	NA	NA
magnesium	2.9E-04	9.7E+00	3.0E-05
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.8E-11	6.0E-03	1.3E-08
uranium-total	8.6E-07	3.0E-03	2.9E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			4.8E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.4E-08	NA	NA
aroclor-1254	2.6E-09	7.7E+00	2.0E-08
aroclor-1260	NA	7.7E+00	NA
arsenic	2.0E-08	1.8E+00	3.5E-08
beryllium	6.4E-09	4.3E+00	2.8E-08
benzo(a)pyrene	2.1E-09	7.3E+00	1.5E-08
cadmium	7.9E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	2.9E-04	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	7.8E-11	1.1E-02	8.6E-13
uranium-total	8.6E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			9.7E-08

000434

Table H.IV–84
Summary of Intake and Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via Incidental Ingestion of Soil/Sediment

Intake Equation = CS X EF X ED X FI X IR

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	50	25	25	13	mg/day
EF	Exposure frequency	64	104	40	40	days/year
ED	Exposure duration	6	12	38	14	year
FI	Fractional Intake	1	1	1	1	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Ra_{226+8d}	3.8E–04	pCi/mg		pCi/mg
Rn_{222}		pCi/mg		pCi/mg
Sr_{90+1d}	1.2E–04	pCi/mg		pCi/mg
Tc_{99}	2.5E–04	pCi/mg		pCi/mg
Th_{230}	6.5E–04	pCi/mg		pCi/mg
$Th_{232+10d}$	3.2E–05	pCi/mg		pCi/mg
$U_{235/236}$		pCi/mg		pCi/mg
U_{238+2d}	2.8E–03	pCi/mg		pCi/mg
		pCi/mg		pCi/mg
		pCi/mg		pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.7E–05	7.8E–10	2.9E–14
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.1E–05	3.6E–11	4.1E–16
Tc_{99}	2.4E–05	1.3E–12	3.1E–17
Th_{230}	6.2E–05	1.3E–11	8.0E–16
$Th_{232+10d}$	3.0E–06	1.7E–10	5.2E–16
$U_{235/236}$	NA	1.6E–11	NA
U_{238+2d}	2.7E–04	2.0E–11	5.3E–15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		3.6E–14

Table H.IV-85
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact with Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		child	youth	adult	senoir adult
SA	Surface area of exposed skin	2000	4138	5750	5750 cm^2/day
AF	Absorbtion factor	csv	csv	csv	csv (unitless)
EF	Exposure frequency	64	104	40	40 days/year
ED	Exposure duration	6	12	38	14 year
CF	Conversion factor	1E-06	1.000E-06	1E-06	1E-06 kg/mg
BW	Body weight	15	43	70	70 kg
AT	Average time for carcinogens	25550	25550	25550	25550 day
AT	Average time for non-carcinogens	2190	4380	13870	5110 day
ABS	Absorbtion factor	csv	csv	csv	csv (unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv

Chemical Concentrations

Compound	ABS	Concentration	Units	Compound	ABS	Concentration	Units
antimony	1.0E-02	3.2E-01	mg/kg		NA		mg/kg
aroclor-1254	6.0E-02	2.5E-02	mg/kg		NA		mg/kg
aroclor-1260	6.0E-02		mg/kg		NA		mg/kg
arsenic	1.0E-03	1.9E-01	mg/kg		NA		mg/kg
beryllium	1.0E-02	6.2E-02	mg/kg		NA		mg/kg
benzo(a)pyrene	3.0E-01	2.0E-02	mg/kg		NA		mg/kg
cadmium	1.0E-02	7.6E-02	mg/kg		NA		mg/kg
1,2-dichloroethane	3.0E-01		mg/kg		NA		mg/kg
magnesium	1.0E-02	2.8E+03	mg/kg		NA		mg/kg
manganese	1.0E-02		mg/kg		NA		mg/kg
mercury	5.0E-02		mg/kg		NA		mg/kg
silver	1.0E-02		mg/kg		NA		mg/kg
2,3,7,8-todd	3.0E-02		mg/kg		NA		mg/kg
trichloroethene	3.0E-01	7.6E-04	mg/kg		NA		mg/kg
uranium-total	1.0E-02	8.3E+00	mg/kg		NA		mg/kg
	NA		mg/kg				

References

Table H.IV-85 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.3E-08	6.0E-05	7.2E-04
aroclor-1254	2.0E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.6E-09	2.9E-04	9.0E-06
beryllium	8.3E-09	5.0E-03	1.7E-06
benzo(a)pyrene	8.0E-08	NA	NA
cadmium	1.0E-08	5.0E-05	2.0E-04
1,2-dichloroethane	NA	NA	NA
magnesium	3.8E-04	4.9E-01	7.8E-04
manganese	NA	4.2E-03	NA
mercury	NA	4.5E-05	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.0E-09	5.9E-03	5.2E-07
uranium-total	1.1E-06	1.5E-04	7.4E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		9.1E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	4.3E-08	NA	NA
aroclor-1254	2.0E-08	1.0E+01	2.0E-07
aroclor-1260	NA	1.0E+01	NA
arsenic	2.6E-09	1.8E+00	4.7E-09
beryllium	8.3E-09	4.3E+00	3.6E-08
benzo(a)pyrene	8.0E-08	NA	NA
cadmium	1.0E-08	NA	NA
1,2-dichloroethane	NA	1.0E-01	NA
magnesium	3.8E-04	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
trichloroethene	3.0E-09	1.1E-02	3.4E-11
uranium-total	1.1E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.4E-07

000437

Table H.IV-86
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Ingestion While Wading

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non-carcinogens	2190	4380	13870	5110	days
CS	Concentration of chemicals in surface water	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E-04	mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	1.14E-03	mg/l			mg/l
beryllium	2.38E-05	mg/l			mg/l
benzo(a)pyrene	1.29E-08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium		mg/l			mg/l
manganese	1.07E-01	mg/l			mg/l
mercury	1.01E-03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total		mg/l			mg/l
		mg/l			

References

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Table H.IV-86 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.07E-09	4.00E-04	5.17E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.27E-08	3.00E-04	7.55E-05
beryllium	4.73E-10	5.00E-03	9.46E-08
benzo(a)pyrene	2.56E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	NA
manganese	2.13E-06	5.00E-03	4.25E-04
mercury	2.01E-08	3.00E-04	6.69E-05
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	NA	3.00E-03	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.73E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.17E-08

000439

Table H.IV–87
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact While Wading

Intake Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
SA	Skin surface area		5130			cm^2
DA	chemicals specific dermal absorbed dose	csv	csv	csv	csv	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E–09	mg/cm^2–day			mg/cm^2–day
arodor–1254		mg/cm^2–day			mg/cm^2–day
arodor–1260		mg/cm^2–day			mg/cm^2–day
arsenic	1.14E–08	mg/cm^2–day			mg/cm^2–day
beryllium	2.38E–10	mg/cm^2–day			mg/cm^2–day
benzo(a)pyrene	7.29E–10	mg/cm^2–day			mg/cm^2–day
cadmium		mg/cm^2–day			mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day			mg/cm^2–day
magnesium		mg/cm^2–day			mg/cm^2–day
manganese	1.07E–06	mg/cm^2–day			mg/cm^2–day
mercury	1.01E–08	mg/cm^2–day			mg/cm^2–day
silver		mg/cm^2–day			mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day			mg/cm^2–day
trichloroethene		mg/cm^2–day			mg/cm^2–day
uranium–total		mg/cm^2–day			mg/cm^2–day
		mg/cm^2–day			

References

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Table H.IV-87 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.03E-09	6.00E-05	5.05E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.32E-08	2.85E-04	1.17E-04
beryllium	6.93E-10	5.00E-03	1.39E-07
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	4.85E-01	NA
manganese	3.12E-06	4.20E-03	7.42E-04
mercury	2.94E-08	4.50E-05	6.54E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	NA	1.50E-04	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			1.56E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	NA	NA	NA
manganese	3.12E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			6.42E-08

Table H.IV–88
Summary of Intake and Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via Incidental Ingestion while Wading

Intake Equation = CS X EF X ED X IRsw

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
Cs	Concentration of radionuclides in surface water	csv	csv	csv	csv	

Ra_{226+8d}	1.5E–03	pCi/l		pCi/l
Rn_{222}		pCi/l		pCi/l
Sr_{90+1d}	1.1E+00	pCi/l		pCi/l
Tc_{99}		pCi/l		pCi/l
Th_{230}	3.1E–03	pCi/l		pCi/l
$Th_{232+10d}$	1.7E–04	pCi/l		pCi/l
$U_{235/236}$	7.5E–03	pCi/l		pCi/l
U_{238+2d}	1.7E–01	pCi/l		pCi/l
		pCi/l		pCi/l
		pCi/l		pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.2E–02	7.8E–10	2.5E–11
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.4E+01	3.6E–11	8.6E–10
Tc_{99}	NA	1.3E–12	NA
Th_{230}	6.7E–02	1.3E–11	8.7E–13
$Th_{232+10d}$	3.6E–03	1.7E–10	6.2E–13
$U_{235/236}$	1.6E–01	1.6E–11	2.6E–12
U_{238+2d}	3.7E+00	2.0E–11	7.3E–11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		9.6E–10

Table H.IV–89
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]+[CR \times EF \times ED \times ET_i \times (1-SH_i)]$

		child	youth	adult	senoir adult	
EF	Fraction of year spent exposured	0.18	0.28	0.11	0.11	(unitless)
ED	Exposure duration	6	12	38	14	years
ET_o	Fraction of day spent outdoors	0.17	0.17	0.17	0.08	(unitless)
ET_i	Fraction of day spent indoors	NA	NA	NA	NA	NA
SH_i	Shield factor indoors	0.5	0.5	0.5	0.5	(unitless)
SH_o	Shield factor outdoors					(unitless)
CR	Radionuclide specific concentrations	csv	csv	csv	csv	

Ra_{226+8d}	3.8E−01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.2E−01	pCi/g	NA	pCi/g
Tc_{99}	2.5E−01	pCi/g	NA	pCi/g
Th_{230}	6.5E−01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.2E−02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.8E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.1E−01	6.0E−06	3.7E−06
Rn_{222}	NA	1.2E−09	NA
Sr_{90+1d}	1.9E−01	NA	NA
Tc_{99}	4.0E−01	6.0E−13	2.4E−13
Th_{230}	1.0E+00	5.4E−11	5.5E−11
$Th_{232+10d}$	5.0E−02	8.5E−06	4.3E−07
$U_{235/236}$	NA	2.4E−07	NA
U_{238+2d}	4.4E+00	5.1E−08	2.2E−07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		4.3E−06

Table H.IV-90
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	26	39	52	26	days/year
ED	Exposure duration	6	12	38	14	years
BWa	Body weight (adult)	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	days
ATa	Average time for non-carcinogens (adult)	2190	4380	13870	5110	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units
antimony		mg/m^3
arodor-1254	1.6E-11	mg/m^3
arodor-1260		mg/m^3
arsenic	9.0E-11	mg/m^3
beryllium	1.4E-11	mg/m^3
benzo(a)pyrene	1.1E-11	mg/m^3
cadmium	1.6E-11	mg/m^3
1,2-dichloroethane		mg/m^3
magnesium	7.7E-07	mg/m^3
manganese		mg/m^3
mercury		mg/m^3
silver		mg/m^3
2,3,7,8-tcdd		mg/m^3
trichloroethene	4.4E-13	mg/m^3
uranium-total	8.9E-09	mg/m^3
		mg/m^3

Compound	Concentration	Units
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3

References

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Table H.IV–90 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	NA	NA
aroclor–1254	4.8E–14	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.7E–13	NA	NA
beryllium	4.3E–14	NA	NA
benzo(a)pyrene	3.4E–14	NA	NA
cadmium	4.9E–14	NA	NA
1,2–dichloroethane	NA	2.9E–03	
magnesium	2.3E–09	NA	NA
manganese	NA	1.4E–05	
mercury	NA	8.6E–05	
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.3E–15	NA	NA
uranium–total	2.7E–11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	4.8E–14	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.7E–13	1.5E+01	4.1E–12
beryllium	4.3E–14	8.4E+00	3.6E–13
benzo(a)pyrene	3.4E–14	6.1E+00	2.1E–13
cadmium	4.9E–14	6.3E+00	3.1E–13
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	2.3E–09	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.3E–15	6.0E–03	8.1E–18
uranium–total	2.7E–11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			5.0E–12

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Table H.IV–91
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via Inhalation of Gases and Particulates

Risk Equation = CA X EF X ED X IR X ET

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ED	Exposure duration	6	12	38	14	years
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	26	39	52	26	days/year
CA	Concentration of radionuclides in air	csv	csv	csv	csv	

Ra_{226+8d}	1.4E–07	pCi/m^3	pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3	pCi/m^3
Sr_{90+1d}	4.8E–08	pCi/m^3	pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3	pCi/m^3
Th_{230}	4.2E–07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	4.0E–09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.0E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.4E–04	7.0E–09	4.5E–12
Rn_{222}	8.3E+03	7.3E–13	6.0E–09
Sr_{90+1d}	2.2E–04	6.2E–11	1.3E–14
Tc_{99}	6.2E–04	8.3E–12	5.1E–15
Th_{230}	1.9E–03	2.9E–08	5.5E–11
$Th_{232+10d}$	1.8E–05	1.1E–07	2.0E–12
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	1.3E–02	2.4E–08	3.2E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		6.4E–09

Table H.IV–92
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion of Soil/Sediment

Risk Equation $= \frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	26	39	52	26	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E–06	1E–06	1E–06	1E–06	kg/mg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non–carcinogens	2190	4380	13870	5110	day
BW	Body weight	15	43	70	70	kg
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.2E–01	mg/kg			mg/kg
aroclor–1254	2.5E–02	mg/kg			mg/kg
aroclor–1260		mg/kg			mg/kg
arsenic	1.9E–01	mg/kg			mg/kg
beryllium	6.2E–02	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	7.6E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.8E+03	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	8.3E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-92 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.4E-09	4.0E-04	2.1E-05
aroclor-1254	6.4E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	5.0E-09	3.0E-04	1.7E-05
beryllium	1.6E-09	5.0E-03	3.2E-07
benzo(a)pyrene	5.2E-10	NA	NA
cadmium	2.0E-09	1.0E-03	2.0E-06
1,2-dichloroethane	NA	NA	NA
magnesium	7.3E-05	9.7E+00	7.6E-06
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.0E-11	6.0E-03	3.3E-09
uranium-total	2.2E-07	3.0E-03	7.2E-05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.2E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	8.4E-09	NA	NA
aroclor-1254	6.4E-10	7.7E+00	4.9E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	5.0E-09	1.8E+00	8.7E-09
beryllium	1.6E-09	4.3E+00	6.9E-09
benzo(a)pyrene	5.2E-10	7.3E+00	3.8E-09
cadmium	2.0E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	7.3E-05	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.0E-11	1.1E-02	2.2E-13
uranium-total	2.2E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.4E-08

Table H.IV-93
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion of Soil/Sediment

Risk Equation = CS X EF X ED X FI X IR

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	26	39	52	26	days/year
ED	Exposure duration	6	12	38	14	year
FI	Fractional Intake	1	1	1	1	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Ra_{226+8d}	3.8E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.2E-04	pCi/mg	pCi/mg
Tc_{99}	2.5E-04	pCi/mg	pCi/mg
Th_{230}	6.5E-04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.2E-05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.8E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.4E-05	7.8E-10	1.1E-14
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	4.3E-06	3.6E-11	1.5E-16
Tc_{99}	9.0E-06	1.3E-12	1.2E-17
Th_{230}	2.3E-05	1.3E-11	3.0E-16
$Th_{232+10d}$	1.1E-06	1.7E-10	1.9E-16
$U_{235/236}$	NA	1.6E-11	NA
U_{238+2d}	9.9E-05	2.0E-11	2.0E-15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.3E-14

Table H.IV–94
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact with Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		child	youth	adult	senoir adult
SA	Surface area of exposed skin	2000	4138	5750	5750 cm^2/day
AF	Absorbtion factor	csv	csv	csv	csv (unitless)
EF	Exposure frequency	26	39	52	26 days/year
ED	Exposure duration	6	12	38	14 year
CF	Conversion factor	1E–06	1.000E–06	1E–06	1E–06 kg/mg
BW	Body weight	15	43	70	70 kg
AT	Average time for carcinogens	25550	25550	25550	25550 day
AT	Average time for non–carcinogens	2190	4380	13870	5110 day
ABS	Absorbtion factor	csv	csv	csv	csv (unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv

Chemical Concentrations

Compound	ABS	Concentration	Units	Compound	ABS	Concentration	Units
antimony	1.0E–02	3.2E–01	mg/kg		NA		mg/kg
arodor–1254	6.0E–02	2.5E–02	mg/kg		NA		mg/kg
arodor–1260	6.0E–02		mg/kg		NA		mg/kg
arsenic	1.0E–03	1.9E–01	mg/kg		NA		mg/kg
beryllium	1.0E–02	6.2E–02	mg/kg		NA		mg/kg
benzo(a)pyrene	3.0E–01	2.0E–02	mg/kg		NA		mg/kg
cadmium	1.0E–02	7.6E–02	mg/kg		NA		mg/kg
1,2–dichloroethane	3.0E–01		mg/kg		NA		mg/kg
magnesium	1.0E–02	2.8E+03	mg/kg		NA		mg/kg
manganese	1.0E–02		mg/kg		NA		mg/kg
mercury	5.0E–02		mg/kg		NA		mg/kg
silver	1.0E–02		mg/kg		NA		mg/kg
2,3,7,8–todd	3.0E–02		mg/kg		NA		mg/kg
trichloroethene	3.0E–01	7.6E–04	mg/kg		NA		mg/kg
uranium–total	1.0E–02	8.3E+00	mg/kg		NA		mg/kg
	NA		mg/kg				

References

000350

6349

Table H.IV–94 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	3.3E–08	6.0E–05	5.4E–04
aroclor–1254	1.5E–08	NA	NA
aroclor–1260	NA	NA	NA
arsenic	1.9E–09	2.9E–04	6.8E–06
beryllium	6.2E–09	5.0E–03	1.2E–06
benzo(a)pyrene	6.1E–08	NA	NA
cadmium	7.7E–09	5.0E–05	1.5E–04
1,2–dichloroethane	NA	NA	NA
magnesium	2.8E–04	4.9E–01	5.9E–04
manganese	NA	4.2E–03	NA
mercury	NA	4.5E–05	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	2.3E–09	5.9E–03	3.9E–07
uranium–total	8.4E–07	1.5E–04	5.6E–03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		6.9E–03

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	3.3E–08	NA	NA
aroclor–1254	1.5E–08	1.0E+01	1.5E–07
aroclor–1260	NA	1.0E+01	NA
arsenic	1.9E–09	1.8E+00	3.6E–09
beryllium	6.2E–09	4.3E+00	2.7E–08
benzo(a)pyrene	6.1E–08	NA	NA
cadmium	7.7E–09	NA	NA
1,2–dichloroethane	NA	1.0E–01	NA
magnesium	2.8E–04	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.0E+05	NA
trichloroethene	2.3E–09	1.1E–02	2.6E–11
uranium–total	8.4E–07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.8E–07

000454

Table H.IV–95
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Ingestion While Wading

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
CS	Concentration of chemicals in surface water	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E–04	mg/l			mg/l
arodor–1254		mg/l			mg/l
arodor–1260		mg/l			mg/l
arsenic	1.14E–03	mg/l			mg/l
beryllium	2.38E–05	mg/l			mg/l
benzo(a)pyrene	1.29E–08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2–dichloroethane		mg/l			mg/l
magnesium		mg/l			mg/l
manganese	1.07E–01	mg/l			mg/l
mercury	1.01E–03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8–tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium–total		mg/l			mg/l
		mg/l			

References

000452

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Table H.IV-95 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.07E-09	4.00E-04	5.17E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.27E-08	3.00E-04	7.55E-05
beryllium	4.73E-10	5.00E-03	9.46E-08
benzo(a)pyrene	2.56E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	NA
manganese	2.13E-06	5.00E-03	4.25E-04
mercury	2.01E-08	3.00E-04	6.69E-05
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	NA	3.00E-03	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.73E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.17E-08

000553

Table H.IV–96
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact While Wading

Risk Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
SA	Skin surface area		5130			cm^2
DA	chemicals specific dermal absorbed dose	csv	csv	csv	csv	

Chemical Concentrations

Compound	DA	Units
antimony	1.04E–09	mg/cm^2–day
arodor–1254		mg/cm^2–day
arodor–1260		mg/cm^2–day
arsenic	1.14E–08	mg/cm^2–day
beryllium	2.38E–10	mg/cm^2–day
benzo(a)pyrene	7.29E–10	mg/cm^2–day
cadmium		mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day
magnesium		mg/cm^2–day
manganese	1.07E–06	mg/cm^2–day
mercury	1.01E–08	mg/cm^2–day
silver		mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day
trichloroethene		mg/cm^2–day
uranium–total		mg/cm^2–day
		mg/cm^2–day

Compound	DA	Units
		mg/cm^2–day
		mg/cm^2–day
		mg/cm^2–day
		mg/cm^2–day
		mg/cm^2–day
		mg/cm^2–day
		mg/cm^2–day
		mg/cm^2–day
		mg/cm^2–day
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		mg/cm^2–day
		mg/cm^2–day

References

000454

634-9

Table H.IV-96 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.03E-09	6.00E-05	5.05E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.32E-08	2.85E-04	1.17E-04
beryllium	6.93E-10	5.00E-03	1.39E-07
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	4.85E-01	NA
manganese	3.12E-06	4.20E-03	7.42E-04
mercury	2.94E-08	4.50E-05	6.54E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	NA	1.50E-04	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.56E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	NA	NA	NA
manganese	3.12E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.42E-08

000255

Table H.IV-97
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion while Wading

Risk Equation = CS X EF X ED X IRsw

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
Cs	Concentration of radionuclides in surface water	csv	csv	csv	csv	

Ra_{226+8d}	1.5E-03	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	1.1E+00	pCi/l	pCi/l
Tc_{99}		pCi/l	pCi/l
Th_{230}	3.1E-03	pCi/l	pCi/l
$Th_{232+10d}$	1.7E-04	pCi/l	pCi/l
$U_{235/236}$	7.5E-03	pCi/l	pCi/l
U_{238+2d}	1.7E-01	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.2E-02	7.8E-10	2.5E-11
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	2.4E+01	3.6E-11	8.6E-10
Tc_{99}	NA	1.3E-12	NA
Th_{230}	6.7E-02	1.3E-11	8.7E-13
$Th_{232+10d}$	3.6E-03	1.7E-10	6.2E-13
$U_{235/236}$	1.6E-01	1.6E-11	2.6E-12
U_{238+2d}	3.7E+00	2.0E-11	7.3E-11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		9.6E-10

Table H.IV–98
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]+[CR \times EF \times ED \times ET_i \times (1-SH_i)]$

		child	youth	adult	senoir adult	
EF	Fraction of year spent exposured	0.07	0.11	0.14	0.07	(unitless)
ED	Exposure duration	6	12	38	14	years
ET_o	Fraction of day spent outdoors	0.04	0.08	0.08	0.04	(unitless)
ET_i	Fraction of day spent indoors	NA	NA	NA	NA	NA
SH_i	Shield factor indoors	0.5	0.5	0.5	0.5	(unitless)
SH_o	Shield factor outdoors					(unitless)
CR	Radionuclide specific concentrations	csv	csv	csv	csv	

Ra_{226+8d}	3.8E−01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.2E−01	pCi/g	NA	pCi/g
Tc_{99}	2.5E−01	pCi/g	NA	pCi/g
Th_{230}	6.5E−01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.2E−02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.8E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.3E−01	6.0E−06	1.4E−06
Rn_{222}	NA	1.2E−09	NA
Sr_{90+1d}	7.0E−02	NA	NA
Tc_{99}	1.5E−01	6.0E−13	8.8E−14
Th_{230}	3.8E−01	5.4E−11	2.0E−11
$Th_{232+10d}$	1.9E−02	8.5E−06	1.6E−07
$U_{235/236}$	NA	2.4E−07	NA
U_{238+2d}	1.6E+00	5.1E−08	8.3E−08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.6E−06

Table H.IV–99
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		youth	adult	
IR	Inhalation rate of gases	0.83	0.83	m^3/hour
ETa	Exposure time (adult)	2	1	hour/day
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure duration (adult)	12	32	Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non–carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/m^3			mg/m^3
aroclor–1254	1.6E–11	mg/m^3			mg/m^3
aroclor–1260		mg/m^3			mg/m^3
arsenic	9.0E–11	mg/m^3			mg/m^3
beryllium	1.4E–11	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E–11	mg/m^3			mg/m^3
cadmium	1.6E–11	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	7.7E–07	mg/m^3			mg/m^3
manganese		mg/m^3			mg/m^3
mercury		mg/m^3			mg/m^3
silver		mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E–13	mg/m^3			mg/m^3
uranium–total	8.9E–09	mg/m^3			mg/m^3
		mg/m^3			

References

000458

Table H.IV-99 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	NA	NA
aroclor-1254	1.5E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.7E-14	NA	NA
beryllium	1.4E-14	NA	NA
benzo(a)pyrene	1.1E-14	NA	NA
cadmium	1.6E-14	NA	NA
1,2-dichloroethane	NA	2.9E-03	
magnesium	7.5E-10	NA	NA
manganese	NA	1.4E-05	
mercury	NA	8.6E-05	
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.3E-16	NA	NA
uranium-total	8.6E-12	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	4.1E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.3E-13	1.5E+01	3.5E-12
beryllium	3.6E-14	8.4E+00	3.0E-13
benzo(a)pyrene	2.9E-14	6.1E+00	1.8E-13
cadmium	4.1E-14	6.3E+00	2.6E-13
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	2.0E-09	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.1E-15	6.0E-03	6.9E-18
uranium-total	2.3E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.2E-12

000459

Table H.IV–100
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via Inhalation of Gases and Particulates

Risk Equation = CA X EF X ED X IR X ET

		youth	adult
IR	Inhalation rate of gases	0.83	0.83 m^3/hour
EFa	Exposure frequency (adult)	110	40 days/year
EDa	Exposure duration	12	32 Year
ETa	Exposure time (adult)	2	1 hour/day
CA	Concentration of radionuclides in air	csv	csv (see table below)

Ra_{226+8d}	1.4E–07	pCi/m^3	pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3	pCi/m^3
Sr_{90+1d}	4.8E–08	pCi/m^3	pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3	pCi/m^3
Th_{230}	4.2E–07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	4.0E–09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.0E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	4.6E–04	7.0E–09	3.2E–12
Rn_{222}	6.0E+03	7.3E–13	4.4E–09
Sr_{90+1d}	1.6E–04	6.2E–11	9.7E–15
Tc_{99}	4.5E–04	8.3E–12	3.7E–15
Th_{230}	1.4E–03	2.9E–08	4.0E–11
$Th_{232+10d}$	1.3E–05	1.1E–07	1.4E–12
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	9.6E–03	2.4E–08	2.3E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		4.6E–09

Table H.IV – 101
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		youth	adult	
IRa	Ingestion rate of soil (adult)	12.5	12.5	mg/day
CF	Conversion factor	1.00E–06	1.00E–06	kg/mg
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure duration (adult)	12	32	Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non–carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in soil	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	3.2E–01	mg/kg			mg/kg
arodor–1254	2.5E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	1.9E–01	mg/kg			mg/kg
beryllium	6.2E–02	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	7.6E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.8E+03	mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury		mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	8.3E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-101 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.2E-08	4.0E-04	3.1E-05
aroclor-1254	9.4E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	7.3E-09	3.0E-04	2.4E-05
beryllium	2.4E-09	5.0E-03	4.7E-07
benzo(a)pyrene	7.6E-10	NA	NA
cadmium	2.9E-09	1.0E-03	2.9E-06
1,2-dichloroethane	NA	NA	NA
magnesium	1.1E-04	9.7E+00	1.1E-05
manganese	NA	1.4E-01	NA
mercury	NA	3.0E-04	NA
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.9E-11	6.0E-03	4.8E-09
uranium-total	3.2E-07	3.0E-03	1.1E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.8E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	7.7E-09	NA	NA
aroclor-1254	5.9E-10	7.7E+00	4.5E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	4.6E-09	1.8E+00	8.1E-09
beryllium	1.5E-09	4.3E+00	6.4E-09
benzo(a)pyrene	4.8E-10	7.3E+00	3.5E-09
cadmium	1.8E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	6.8E-05	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.8E-11	1.1E-02	2.0E-13
uranium-total	2.0E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.2E-08

Table H.IV–102
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

Risk Equation = CS X EF X ED X FI X IR

		youth	adult	
IRa	Ingestion rate of soil (adult)	12.5	12.5	mg/day
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure Duration	12	32	Year
FI	Fractional Intake	1	1	(unitless)
CS	Concentration of radionuclides in soil	csv	csv	

Ra_{226+8d}	3.8E–04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.2E–04	pCi/mg	pCi/mg
Tc_{99}	2.5E–04	pCi/mg	pCi/mg
Th_{230}	6.5E–04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.2E–05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.8E–03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.2E+01	7.8E–10	9.7E–09
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	3.9E+00	3.6E–11	1.4E–10
Tc_{99}	8.1E+00	1.3E–12	1.1E–11
Th_{230}	2.1E+01	1.3E–11	2.7E–10
$Th_{232+10d}$	1.0E+00	1.7E–10	1.8E–10
$U_{235/236}$	NA	1.6E–11	NA
U_{238+2d}	9.0E+01	2.0E–11	1.8E–09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.2E–08

Table H.IV – 103
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact with Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		youth	adult	
SA	Surface area of exposed skin (adult)	4200	5750	cm^2/day
AF	Soil to skin adherence factor	1	1	mg/cm^2
ABS	chemicals specific absorbtion factor	csv	csv	
CF	Conversion factor	1.0E–06	1.0E–06	kg/mg
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure duration (adult)	12	32	Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non–carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in soil	csv	csv	

Chemical Concentrations

Compound	ABS	Concentration	Units
antimony	1.0E–02	3.2E–01	mg/kg
arodor–1254	6.0E–02	2.5E–02	mg/kg
arodor–1260	6.0E–02		mg/kg
arsenic	1.0E–03	1.9E–01	mg/kg
beryllium	1.0E–02	6.2E–02	mg/kg
benzo(a)pyrene	3.0E–01	2.0E–02	mg/kg
cadmium	1.0E–02	7.6E–02	mg/kg
1,2–dichloroethane	3.0E–01		mg/kg
magnesium	1.0E–02	2.8E+03	mg/kg
manganese	1.0E–02		mg/kg
mercury	5.0E–02		mg/kg
silver	1.0E–02		mg/kg
2,3,7,8–tcdd	3.0E–02		mg/kg
trichloroethene	3.0E–01	7.6E–04	mg/kg
uranium–total	1.0E–02	8.3E+00	mg/kg
	NA		mg/kg

Compound	ABS	Concentration	Units
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg

References

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Table H.IV-103 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.7E-08	6.0E-05	7.8E-04
aroclor-1254	2.2E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.8E-09	2.9E-04	9.8E-06
beryllium	9.0E-09	5.0E-03	1.8E-06
benzo(a)pyrene	8.7E-08	NA	NA
cadmium	1.1E-08	5.0E-05	2.2E-04
1,2-dichloroethane	NA	NA	NA
magnesium	4.1E-04	4.9E-01	8.5E-04
manganese	NA	4.2E-03	NA
mercury	NA	4.5E-05	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.3E-09	5.9E-03	5.6E-07
uranium-total	1.2E-06	1.5E-04	8.1E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		9.9E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.0E-08	NA	NA
aroclor-1254	1.4E-08	1.0E+01	1.4E-07
aroclor-1260	NA	1.0E+01	NA
arsenic	1.8E-09	1.8E+00	3.2E-09
beryllium	5.7E-09	4.3E+00	2.4E-08
benzo(a)pyrene	5.5E-08	NA	NA
cadmium	7.0E-09	NA	NA
1,2-dichloroethane	NA	1.0E-01	NA
magnesium	2.6E-04	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
trichloroethene	2.1E-09	1.1E-02	2.3E-11
uranium-total	7.6E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.7E-07

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Table H.IV-104
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Ingestion While Wading

Risk Equation $= \frac{CS \times EF \times ED \times IR}{BW \times AT}$

		youth	adult	
IRsw	Ingestion rate of surface water	0.035		l/day
EFa	Exposure frequency (adult)	52		days/year
EDa	Exposure duration (adult)	12		Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in surface water	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E-04	mg/l			mg/l
aroclor-1254		mg/l			mg/l
aroclor-1260		mg/l			mg/l
arsenic	1.14E-03	mg/l			mg/l
beryllium	2.38E-05	mg/l			mg/l
benzo(a)pyrene	1.29E-08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium		mg/l			mg/l
manganese	1.07E-01	mg/l			mg/l
mercury	1.01E-03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total		mg/l			mg/l
		mg/l			

References

Table H.IV-104
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.29E-09	4.00E-04	8.22E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.61E-08	3.00E-04	1.20E-04
beryllium	7.53E-10	5.00E-03	1.51E-07
benzo(a)pyrene	4.08E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	NA
manganese	3.38E-06	5.00E-03	6.77E-04
mercury	3.19E-08	3.00E-04	1.06E-04
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	NA	3.00E-03	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		9.12E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.17E-08

Table H.IV-105
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact While Wading

Risk Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		youth	adult	
EFa	Exposure frequency (adult)	52		days/year
EDa	Exposure duration (adult)	12		Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
DA	chemicals specific dermal absorbed dose	csv	csv	
SAa	Skin surface area (adult)	5130		cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E-09	mg/cm^2-day			mg/cm^2-day
aroclor-1254		mg/cm^2-day			mg/cm^2-day
aroclor-1260		mg/cm^2-day			mg/cm^2-day
arsenic	1.14E-08	mg/cm^2-day			mg/cm^2-day
beryllium	2.38E-10	mg/cm^2-day			mg/cm^2-day
benzo(a)pyrene	7.29E-10	mg/cm^2-day			mg/cm^2-day
cadmium		mg/cm^2-day			mg/cm^2-day
1,2-dichloroethane		mg/cm^2-day			mg/cm^2-day
magnesium		mg/cm^2-day			mg/cm^2-day
manganese	1.07E-06	mg/cm^2-day			mg/cm^2-day
mercury	1.01E-08	mg/cm^2-day			mg/cm^2-day
silver		mg/cm^2-day			mg/cm^2-day
2,3,7,8-tcdd		mg/cm^2-day			mg/cm^2-day
trichloroethene		mg/cm^2-day			mg/cm^2-day
uranium-total		mg/cm^2-day			mg/cm^2-day
		mg/cm^2-day			

References

Table H.IV-105 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.82E-09	6.00E-05	8.03E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	5.28E-08	2.85E-04	1.85E-04
beryllium	1.10E-09	5.00E-03	2.21E-07
benzo(a)pyrene	3.38E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	4.85E-01	NA
manganese	4.96E-06	4.20E-03	1.18E-03
mercury	4.68E-08	4.50E-05	1.04E-03
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	NA	1.50E-04	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.49E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	NA	NA	NA
manganese	3.12E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.42E-08

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Table H.IV–106
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion while Wading

Risk Equation = CS X EF X ED X FI X IRsw

		youth	adult	
IRsw	Ingestion rate of surface water	0.035		l/day
EFa	Exposure frequency (adult)	52		days/year
EDa	Exposure duration (adult)	12		Year
FI	Fractional intake for radionuclides	1		1 (Unitless)
Cs	Concentration of radionuclides in surface water	csv	csv	

Ra_{226+8d}	1.5E–03	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	1.1E+00	pCi/l	pCi/l
Tc_{99}		pCi/l	pCi/l
Th_{230}	3.1E–03	pCi/l	pCi/l
$Th_{232+10d}$	1.7E–04	pCi/l	pCi/l
$U_{235/236}$	7.5E–03	pCi/l	pCi/l
U_{238+2d}	1.7E–01	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.2E–02	7.8E–10	2.5E–11
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.4E+01	3.6E–11	8.6E–10
Tc_{99}	NA	1.3E–12	NA
Th_{230}	6.7E–02	1.3E–11	8.7E–13
$Th_{232+10d}$	3.6E–03	1.7E–10	6.2E–13
$U_{235/236}$	1.6E–01	1.6E–11	2.6E–12
U_{238+2d}	3.7E+00	2.0E–11	7.3E–11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		9.6E–10

Table H.IV–107
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]$

		youth	adult
EFa	Fraction of year spent exposured (adult)	0.3	0.11 (unitless)
EDa	Exposure duration (adult)	12	32 Year
ET_{oa}	Fraction of day spent outdoors (adult)	0.08	0.04 (unitless)
SH_o	Shield factor outdoors		(unitless)
CR	Radionuclide specific concentrations	csv	csv (see table below)

Ra_{226+8d}	3.8E−01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.2E−01	pCi/g	NA	pCi/g
Tc_{99}	2.5E−01	pCi/g	NA	pCi/g
Th_{230}	6.5E−01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.2E−02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.8E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E−01	6.0E−06	9.9E−07
Rn_{222}	NA	1.2E−09	NA
Sr_{90+1d}	5.1E−02	NA	NA
Tc_{99}	1.1E−01	6.0E−13	6.4E−14
Th_{230}	2.8E−01	5.4E−11	1.5E−11
$Th_{232+10d}$	1.4E−02	8.5E−06	1.2E−07
$U_{235/236}$	NA	2.4E−07	NA
U_{238+2d}	1.2E+00	5.1E−08	6.1E−08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation		=	1.2E−06

Table H.IV-108
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Meat Products

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E-10	mg/kg			mg/kg
aroclor-1254		mg/kg			mg/kg
aroclor-1260		mg/kg			mg/kg
arsenic		mg/kg			mg/kg
beryllium	9.4E-11	mg/kg			mg/kg
benzo(a)pyrene	1.1E-11	mg/kg			mg/kg
cadmium		mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium		mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury	1.0E-06	mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene		mg/kg			mg/kg
uranium-total		mg/kg			mg/kg
		mg/kg			

References

Table H.IV-108 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.4E-13	4.0E-04	1.1E-09
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.0E-04	NA
beryllium	9.7E-14	5.0E-03	1.9E-11
benzo(a)pyrene	1.2E-14	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.7E+00	NA
manganese	NA	1.4E-01	NA
mercury	1.1E-09	3.0E-04	3.5E-06
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	NA	3.0E-03	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.5E-06

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	4.4E-13	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	NA	1.8E+00	NA
beryllium	9.7E-14	4.3E+00	4.2E-13
benzo(a)pyrene	1.2E-14	7.3E+00	8.4E-14
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	1.1E-09	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		5.0E-13

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Table H.IV–109
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Meat Products

risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	9.2E–10	pCi/kg	pCi/kg
Rn_{222}	ERR	pCi/kg	pCi/kg
Sr_{90+1d}	1.1E–06	pCi/kg	pCi/kg
Tc_{99}	9.5E–04	pCi/kg	pCi/kg
Th_{230}	3.7E–10	pCi/kg	pCi/kg
$Th_{232+10d}$	2.5E–12	pCi/kg	pCi/kg
$U_{235/236}$	6.6E–09	pCi/kg	pCi/kg
U_{238+2d}	1.5E–07	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.7E–06	7.8E–10	1.3E–15
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.1E–03	3.6E–11	7.4E–14
Tc_{99}	1.8E+00	1.3E–12	2.3E–12
Th_{230}	6.8E–07	1.3E–11	8.9E–18
$Th_{232+10d}$	4.7E–09	1.7E–10	8.0E–19
$U_{235/236}$	1.2E–05	1.6E–11	2.0E–16
U_{238+2d}	2.8E–04	2.0E–11	5.5E–15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.4E–12

Table H.IV–110
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Dairy Products

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.1E–08	mg/kg			mg/kg
aroclor–1254		mg/kg			mg/kg
aroclor–1260		mg/kg			mg/kg
arsenic		mg/kg			mg/kg
beryllium	1.0E–10	mg/kg			mg/kg
benzo(a)pyrene	4.2E–09	mg/kg			mg/kg
cadmium		mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium		mg/kg			mg/kg
manganese		mg/kg			mg/kg
mercury	2.2E–06	mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene		mg/kg			mg/kg
uranium–total		mg/kg			mg/kg
		mg/kg			

References

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Table H.IV-110 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.1E-10	4.0E-04	5.2E-07
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.0E-04	NA
beryllium	4.1E-13	5.0E-03	8.3E-11
benzo(a)pyrene	1.7E-11	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.7E+00	NA
manganese	NA	1.4E-01	NA
mercury	9.1E-09	3.0E-04	3.0E-05
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	NA	3.0E-03	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.1E-05

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.1E-10	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	NA	1.8E+00	NA
beryllium	4.1E-13	4.3E+00	1.8E-12
benzo(a)pyrene	1.7E-11	7.3E+00	1.3E-10
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	9.1E-09	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.3E-10

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Table H.IV–111
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Dairy Products

risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	2.0E–06	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	6.7E–03	pCi/kg	pCi/kg
Tc_{99}	1.3E+00	pCi/kg	pCi/kg
Th_{230}	3.7E–07	pCi/kg	pCi/kg
$Th_{232+10d}$	2.5E–09	pCi/kg	pCi/kg
$U_{235/236}$	2.4E–05	pCi/kg	pCi/kg
U_{238+2d}	5.4E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.5E–02	7.8E–10	1.1E–11
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	4.9E+01	3.6E–11	1.8E–09
Tc_{99}	9.8E+03	1.3E–12	1.3E–08
Th_{230}	2.7E–03	1.3E–11	3.5E–14
$Th_{232+10d}$	1.9E–05	1.7E–10	3.2E–15
$U_{235/236}$	1.7E–01	1.6E–11	2.8E–12
U_{238+2d}	3.9E+00	2.0E–11	7.9E–11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.5E–08

Table H.IV–112
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User
Via Ingestion of Vegetables and Fruits

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E–05	mg/kg		ERR	mg/kg
aroclor–1254		mg/kg		ERR	mg/kg
aroclor–1260		mg/kg		ERR	mg/kg
arsenic		mg/kg		ERR	mg/kg
beryllium	9.2E–06	mg/kg		ERR	mg/kg
benzo(a)pyrene	3.5E–08	mg/kg		ERR	mg/kg
cadmium		mg/kg		ERR	mg/kg
1,2–dichloroethane		mg/kg		ERR	mg/kg
magnesium		mg/kg		ERR	mg/kg
manganese		mg/kg		ERR	mg/kg
mercury	4.0E–04	mg/kg		ERR	mg/kg
silver		mg/kg		ERR	mg/kg
2,3,7,8–tcdd		mg/kg		ERR	mg/kg
trichloroethene		mg/kg		ERR	mg/kg
uranium–total		mg/kg		ERR	mg/kg
	ERR	mg/kg			

References

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Table H.IV-112 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.5E-08	4.0E-04	8.7E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.0E-04	NA
beryllium	7.6E-09	5.0E-03	1.5E-06
benzo(a)pyrene	2.9E-11	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.7E+00	NA
manganese	NA	1.4E-01	NA
mercury	3.4E-07	3.0E-04	1.1E-03
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	NA	3.0E-03	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.2E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.5E-08	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	NA	1.8E+00	NA
beryllium	7.6E-09	4.3E+00	3.3E-08
benzo(a)pyrene	2.9E-11	7.3E+00	2.1E-10
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	3.4E-07	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.3E-08

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Table H.IV–113
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Vegetables and Fruits

risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	3.6E−04	pCi/kg	ERR	pCi/kg
Rn_{222}	ERR	pCi/kg	ERR	pCi/kg
Sr_{90+1d}	3.7E−01	pCi/kg	ERR	pCi/kg
Tc_{99}	1.1E+01	pCi/kg	ERR	pCi/kg
Th_{230}	6.0E−03	pCi/kg	ERR	pCi/kg
$Th_{232+10d}$	4.1E−05	pCi/kg	ERR	pCi/kg
$U_{235/236}$	3.2E−03	pCi/kg	ERR	pCi/kg
U_{238+2d}	7.3E−02	pCi/kg	ERR	pCi/kg
	ERR	pCi/kg	ERR	pCi/kg
	ERR	pCi/kg	ERR	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	5.4E−01	7.8E−10	4.2E−10
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	5.5E+02	3.6E−11	2.0E−08
Tc_{99}	1.7E+04	1.3E−12	2.2E−08
Th_{230}	9.0E+00	1.3E−11	1.2E−10
$Th_{232+10d}$	6.2E−02	1.7E−10	1.0E−11
$U_{235/236}$	4.8E+00	1.6E−11	7.7E−11
U_{238+2d}	1.1E+02	2.0E−11	2.2E−09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 4.5E−08

Table H.IV-114
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Residential)
Via Drinking Water Ingestion

risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	8.48E-06	mg/l			mg/l
aroclor-1254		mg/l			mg/l
aroclor-1260		mg/l			mg/l
arsenic		mg/l			mg/l
beryllium	1.87E-06	mg/l			mg/l
benzo(a)pyrene	7.08E-09	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium		mg/l			mg/l
manganese		mg/l			mg/l
mercury	8.18E-05	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total		mg/l			mg/l
		mg/l			

References

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Table H.IV-114
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Residential)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.32E-07	4.00E-04	5.81E-04
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.00E-04	
beryllium	5.12E-08	5.00E-03	1.02E-05
benzo(a)pyrene	1.94E-10	NA	NA
cadmium	NA	1.00E-03	
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	
manganese	NA	1.40E-01	
mercury	2.24E-06	3.00E-04	7.47E-03
silver	NA	5.00E-03	
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	
uranium-total	NA	3.00E-03	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		8.06E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.32E-07	NA	NA
aroclor-1254	NA	7.70E+00	
aroclor-1260	NA	7.70E+00	
arsenic	NA	1.75E+00	
beryllium	5.12E-08	4.30E+00	2.20E-07
benzo(a)pyrene	1.94E-10	7.30E+00	1.42E-09
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	2.24E-06	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	
trichloroethene	NA	1.10E-02	
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.22E-07

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Table H.IV–115
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Residential)
Via Ingestion of Drinking Water

risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}	7.4E−05	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	7.4E−02	pCi/l	pCi/l
Tc_{99}	2.2E+00	pCi/l	pCi/l
Th_{230}	1.2E−03	pCi/l	pCi/l
$Th_{232+10d}$	8.4E−06	pCi/l	pCi/l
$U_{235/236}$	6.6E−04	pCi/l	pCi/l
U_{238+2d}	1.5E−02	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.6E+00	7.8E−10	2.8E−09
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	3.6E+03	3.6E−11	1.3E−07
Tc_{99}	1.1E+05	1.3E−12	1.4E−07
Th_{230}	6.0E+01	1.3E−11	7.8E−10
$Th_{232+10d}$	4.1E−01	1.7E−10	7.0E−11
$U_{235/236}$	3.2E+01	1.6E−11	5.2E−10
U_{238+2d}	7.3E+02	2.0E−11	1.5E−08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.9E−07

Table H.IV-116
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Residential)
Via Dermal Contact while Bathing

risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2-day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	2.12E-11	mg/cm^2-day			mg/cm^2-day
aroclor-1254		mg/cm^2-day			mg/cm^2-day
aroclor-1260		mg/cm^2-day			mg/cm^2-day
arsenic		mg/cm^2-day			mg/cm^2-day
beryllium	4.68E-12	mg/cm^2-day			mg/cm^2-day
benzo(a)pyrene	2.00E-10	mg/cm^2-day			mg/cm^2-day
cadmium		mg/cm^2-day			mg/cm^2-day
1,2-dichloroethane		mg/cm^2-day			mg/cm^2-day
magnesium		mg/cm^2-day			mg/cm^2-day
manganese		mg/cm^2-day			mg/cm^2-day
mercury	2.05E-10	mg/cm^2-day			mg/cm^2-day
silver		mg/cm^2-day			mg/cm^2-day
2,3,7,8-tcdd		mg/cm^2-day			mg/cm^2-day
trichloroethene		mg/cm^2-day			mg/cm^2-day
uranium-total		mg/cm^2-day			mg/cm^2-day
		mg/cm^2-day			

References

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Table H.IV-116 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	6.68E-09	6.00E-05	1.11E-04
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	2.85E-04	
beryllium	1.47E-09	5.00E-03	2.95E-07
benzo(a)pyrene	6.30E-08	NA	NA
cadmium	NA	5.00E-05	
1,2-dichloroethane	NA	NA	NA
magnesium	NA	4.85E-01	
manganese	NA	4.20E-03	
mercury	6.44E-08	4.50E-05	1.43E-03
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	
uranium-total	NA	1.50E-04	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.54E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.68E-09	NA	NA
aroclor-1254	NA	1.03E+01	
aroclor-1260	NA	1.03E+01	
arsenic	NA	1.84E+00	
beryllium	1.47E-09	4.30E+00	6.33E-09
benzo(a)pyrene	6.30E-08	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	6.44E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	NA	1.12E-02	
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.33E-09

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Table H.IV–117
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Ingestion of Fish

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fish	0.054 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	122 days/year
EDn	Exposure duration for non–carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	10950 days
CS	Concentration of chemicals in meat	csv

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	8.5E–06	mg/kg		NA	mg/kg
aroclor–1254	NA	mg/kg		NA	mg/kg
aroclor–1260	NA	mg/kg		NA	mg/kg
arsenic	NA	mg/kg		NA	mg/kg
beryllium	3.6E–05	mg/kg		NA	mg/kg
benzo(a)pyrene	1.8E–04	mg/kg		NA	mg/kg
cadmium	NA	mg/kg		NA	mg/kg
1,2–dichloroethane	NA	mg/kg		NA	mg/kg
magnesium	NA	mg/kg		NA	mg/kg
manganese	NA	mg/kg		NA	mg/kg
mercury	4.5E–01	mg/kg		NA	mg/kg
silver	NA	mg/kg		NA	mg/kg
2,3,7,8–tcdd	NA	mg/kg		NA	mg/kg
trichloroethene	NA	mg/kg		NA	mg/kg
uranium–total	NA	mg/kg		NA	mg/kg
	NA	mg/kg			

References

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Table H.IV-117 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Ingestion of Fish

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.2E-09	4.0E-04	5.5E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.0E-04	NA
beryllium	9.2E-09	5.0E-03	1.8E-06
benzo(a)pyrene	4.6E-08	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.7E+00	NA
manganese	NA	1.4E-01	NA
mercury	1.2E-04	3.0E-04	3.9E-01
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	NA	3.0E-03	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.9E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF (mg/kg-day)	ILCR (unitless)
antimony	9.4E-10	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	NA	1.8E+00	NA
beryllium	3.9E-09	4.3E+00	1.7E-08
benzo(a)pyrene	2.0E-08	7.3E+00	1.5E-07
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	5.0E-05	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.6E-07

28-300

Table H.IV–118
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Recreational)
Via Ingestion of Fish

risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.054 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	122 days/year
EDn	Exposure duration	30 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	3.7E–06	pCi/kg	NA	pCi/kg
Rn_{222}	NA	pCi/kg	NA	pCi/kg
Sr_{90+1d}	2.2E–03	pCi/kg	NA	pCi/kg
Tc_{99}	3.3E–02	pCi/kg	NA	pCi/kg
Th_{230}	3.7E–05	pCi/kg	NA	pCi/kg
$Th_{232+10d}$	2.5E–07	pCi/kg	NA	pCi/kg
$U_{235/236}$	1.3E–06	pCi/kg	NA	pCi/kg
U_{238+2d}	3.0E–05	pCi/kg	NA	pCi/kg
	NA	pCi/kg	NA	pCi/kg
	NA	pCi/kg	NA	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.8E–07	7.8E–10	1.4E–16
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.2E–04	3.6E–11	7.9E–15
Tc_{99}	1.9E–01	1.3E–12	2.4E–13
Th_{230}	7.3E–08	1.3E–11	9.5E–19
$Th_{232+10d}$	5.0E–10	1.7E–10	8.5E–20
$U_{235/236}$	1.3E–06	1.6E–11	2.1E–17
U_{238+2d}	2.9E–05	2.0E–11	5.9E–16
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.5E–13

Table II.IV-119
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Incidental Ingestion While Wading

risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non-carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	10950 days
ATn	Average time for non-carcinogens (EDn x 365)	10950 days
CS	Concentration of chemicals in surface water	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	8.48E-06	mg/cm^2-d			mg/cm^2-d
aroclor-1254		mg/cm^2-d			mg/cm^2-d
aroclor-1260		mg/cm^2-d			mg/cm^2-d
arsenic		mg/cm^2-d			mg/cm^2-d
beryllium	1.87E-06	mg/cm^2-d			mg/cm^2-d
benzo(a)pyrene	7.08E-09	mg/cm^2-d			mg/cm^2-d
cadmium		mg/cm^2-d			mg/cm^2-d
1,2-dichloroethane		mg/cm^2-d			mg/cm^2-d
magnesium		mg/cm^2-d			mg/cm^2-d
manganese		mg/cm^2-d			mg/cm^2-d
mercury	8.18E-05	mg/cm^2-d			mg/cm^2-d
silver		mg/cm^2-d			mg/cm^2-d
2,3,7,8-tcdd		mg/cm^2-d			mg/cm^2-d
trichloroethene		mg/cm^2-d			mg/cm^2-d
uranium-total		mg/cm^2-d			mg/cm^2-d
		mg/cm^2-d			

References

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Table H.IV-119 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Incidental Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.13E-11	4.00E-04	2.03E-07
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	3.00E-04	NA
beryllium	1.79E-11	5.00E-03	3.59E-09
benzo(a)pyrene	6.79E-14	NA	ERR
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.70E+00	NA
manganese	NA	5.00E-03	NA
mercury	7.84E-10	3.00E-04	2.61E-06
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	NA	3.00E-03	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		ERR

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	8.13E-11	NA	
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	NA	1.75E+00	NA
beryllium	1.79E-11	4.30E+00	7.71E-11
benzo(a)pyrene	6.79E-14	7.30E+00	4.96E-13
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	7.84E-10	NA	
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		7.76E-11

005000

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Table H.IV–120
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Recreational)
Via Incidental Ingestion while Wading

risk Equation = Cs X EF X ED X FI X IR

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non–carcinogens	30 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cs	Concentration of radionuclides in surface water	

Ra_{226+8d}	7.37E–05	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	7.43E–02	pCi/l	pCi/l
Tc_{99}	2.23E+00	pCi/l	pCi/l
Th_{230}	1.23E–03	pCi/l	pCi/l
$Th_{232+10d}$	8.44E–06	pCi/l	pCi/l
$U_{235/236}$	6.61E–04	pCi/l	pCi/l
U_{238+2d}	1.49E–02	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	5.42E–04	7.80E–10	4.23E–13
Rn_{222}	NA	1.40E–12	NA
Sr_{90+1d}	5.46E–01	3.60E–11	1.97E–11
Tc_{99}	1.64E+01	1.30E–12	2.13E–11
Th_{230}	9.04E–03	1.30E–11	1.18E–13
$Th_{232+10d}$	6.20E–05	1.70E–10	1.05E–14
$U_{235/236}$	4.86E–03	1.60E–11	7.77E–14
U_{238+2d}	1.10E–01	2.00E–11	2.19E–12
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		4.38E–11

Table H.IV-121
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Dermal Contact while Wading

risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2-day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non-carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	2.12E-11	mg/cm^2-day			mg/cm^2-day
aroclor-1254		mg/cm^2-day			mg/cm^2-day
aroclor-1260		mg/cm^2-day			mg/cm^2-day
arsenic		mg/cm^2-day			mg/cm^2-day
beryllium	4.68E-12	mg/cm^2-day			mg/cm^2-day
benzo(a)pyrene	2.00E-10	mg/cm^2-day			mg/cm^2-day
cadmium		mg/cm^2-day			mg/cm^2-day
1,2-dichloroethane		mg/cm^2-day			mg/cm^2-day
magnesium		mg/cm^2-day			mg/cm^2-day
manganese		mg/cm^2-day			mg/cm^2-day
mercury	2.05E-10	mg/cm^2-day			mg/cm^2-day
silver		mg/cm^2-day			mg/cm^2-day
2,3,7,8-tcdd		mg/cm^2-day			mg/cm^2-day
trichloroethene		mg/cm^2-day			mg/cm^2-day
uranium-total		mg/cm^2-day			mg/cm^2-day
		mg/cm^2-day			

References

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Table H.IV-121 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.25E-09	6.00E-05	2.08E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	NA	2.85E-04	
beryllium	2.75E-10	5.00E-03	5.50E-08
benzo(a)pyrene	5.88E-09	NA	NA
cadmium	NA	5.00E-05	
1,2-dichloroethane	NA	NA	NA
magnesium	NA	4.85E-01	
manganese	NA	4.20E-03	
mercury	1.20E-08	4.50E-05	2.67E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	
uranium-total	NA	1.50E-04	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.88E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
antimony	5.34E-10	NA	NA
aroclor-1254	NA	1.03E+01	
aroclor-1260	NA	1.03E+01	
arsenic	NA	1.84E+00	
beryllium	1.18E-10	4.30E+00	5.07E-10
benzo(a)pyrene	2.52E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	5.15E-09	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	NA	1.12E-02	
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		5.07E-10

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ATTACHMENT H.V
BACKGROUND CONTRIBUTIONS TO RISK

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H.V BACKGROUND CONTRIBUTIONS TO RISK

The consideration of background concentrations plays an important role in the development of risk assessment. Many background constituents occur naturally in concentrations that present potential toxic and/or carcinogenic risks. Ignoring the risks contributed by background concentrations may result in virtually unattainable cleanup levels, both from an economic and engineering standpoint.

Because some the chemicals and radionuclides found at the FEMP site occur naturally, it is reasonable to consider their contributions to risk. The approach taken for the CRARE subtracts background concentrations for those chemicals and radionuclides deemed to occur naturally to present only the incremental risk as a result of FEMP operations.

This attachment presents optional approaches used to quantify risk to the 11 RME receptors identified in Section H.4.0 of this CRARE, using various assumptions with respect to background contributions. The purpose of this analysis is to evaluate the effect on risk calculations as a result of background considerations.

In addition to the approach taken by the CRARE, two other approaches were taken to evaluate the effects on risk as a result of background contributions. The methodology for quantifying risk is the same for the three approaches. However, exposure-point concentrations differ depending on the consideration of background contributions. A discussion of each approach is presented below.

Option A evaluated the "total risk" to hypothetical receptors from the postremedial FEMP site. Under this option, exposure-point concentrations were developed that included the levels contributed as a result of naturally occurring background compounds. Table H.V-1 presents the exposure-point concentrations developed to estimate total risk.

Option B evaluated the total risk minus contributions from naturally occurring radionuclide levels. A second set of exposure point concentrations were developed for this option and are presented in Table H.V-1.

The CRARE approach accounts for contributions from background levels of radionuclides and inorganic compounds. Representative background concentrations for radionuclides and inorganic compounds were subtracted from the COC-specific site-wide average concentration to yield a concentration representing incremental risk. Incremental risk (i.e., the risk posed as a result of residual concentrations above background) were calculated for the 11 RME receptors. These risks are presented in Attachment IV and summarized for comparison purposes in this attachment.

TABLE H.V-1

OPTION A
EXPOSURE POINT CONCENTRATIONS

COC	On-Air	On-Air	Off-Air	Off-SL	On-GW	Off-GW	On-SED	GMR-SWF	Off-SL	Site Contribution PH
	On-Site Air Max	On-Site Air Avg	Fenceline Off-Site Air	On-Site Soil Avg	Future On-Site GW Well 13	Future Off-Site GW Well 2071	Future On-Site Surface Water	Future GM River Surface Water	Future Off-Site Soil	Future Off-Site Air
	pCi/m^3 mg/m^3	pCi/m^3 mg/m^3	pCi/m^3 mg/m^3	pCi/g mg/kg	pCi/L mg/L	pCi/L mg/L	pCi/L mg/L	pCi/L mg/L	pCi/g mg/kg	$pCi/m^3 mg/m^3$
Radionuclides										
Radium	1.57×10^{-6}	8.16×10^{-7}	8.16×10^{-7}	1.60×10^{0}	5.90×10^{-1}		3.51×10^{-1}	4.10×10^{-1}	9.00×10^{-1}	5.58×10^{-7}
Radon	2.20×10^{1}	1.13×10^{1}	1.13×10^{1}							7.54×10^{0}
Strontium	2.38×10^{-7}	1.86×10^{-7}	1.86×10^{-7}	3.69×10^{-1}	6.78×10^{-1}	6.50×10^{-1}	2.05×10^{0}	7.43×10^{-2}	2.65×10^{-1}	1.41×10^{-7}
Technetium	1.59×10^{-7}	1.38×10^{-7}	1.38×10^{-7}	2.50×10^{-1}	3.88×10^{1}	2.24×10^{1}		2.23×10^{0}	2.50×10^{-1}	3.34×10^{-7}
Thorium	1.80×10^{-6}	1.25×10^{-6}	1.25×10^{-6}	2.14×10^{0}			3.06×10^{-3}	3.61×10^{-1}	1.77×10^{0}	9.41×10^{-7}
Thorium	6.97×10^{-7}	6.01×10^{-7}	6.01×10^{-7}	1.11×10^{0}			1.66×10^{-4}	8.44×10^{-6}	8.98×10^{-1}	4.64×10^{-7}
Uranium	5.27×10^{-8}	4.65×10^{-8}	4.65×10^{-8}	7.06×10^{-2}	2.27×10^{-1}	1.77×10^{-1}	7.45×10^{-5}	2.51×10^{-1}	1.12×10^{-1}	4.55×10^{-8}
Uranium	3.87×10^{-6}	3.56×10^{-6}	3.56×10^{-6}	3.85×10^{0}	3.31×10^{0}	2.17×10^{0}	8.98×10^{-1}	7.75×10^{-1}	2.40×10^{0}	2.09×10^{-6}
Inorganics/Organics										
Antimony	2.79×10^{-9}	2.02×10^{-9}	2.02×10^{-9}	3.97×10^{0}			1.04×10^{-4}	8.48×10^{-6}	1.30×10^{0}	1.17×10^{-9}
Aroclor-1254	5.27×10^{-11}	1.58×10^{-11}	1.58×10^{-11}	2.46×10^{-2}					2.20×10^{-2}	1.18×10^{-11}
Aroclor-1260										
Arsenic	3.86×10^{-9}	3.16×10^{-9}	3.16×10^{-9}	5.75×10^{0}	6.28×10^{-7}	2.69×10^{-4}	1.14×10^{-3}	8.72×10^{-5}	3.79×10^{0}	2.23×10^{-9}
Beryllium	4.56×10^{-10}	3.46×10^{-10}	3.46×10^{-10}	6.62×10^{-1}			2.38×10^{-5}	1.87×10^{-6}	4.49×10^{-1}	2.51×10^{-10}
Benzo(a)pyrene	1.28×10^{-11}	1.11×10^{-11}	1.11×10^{-11}	2.00×10^{-2}			1.29×10^{-8}	7.08×10^{-9}	2.00×10^{-2}	9.34×10^{-12}
Cadmium	3.91×10^{-10}	3.03×10^{-10}	3.03×10^{-10}	5.96×10^{-1}					4.90×10^{-1}	2.43×10^{-10}
1,2-Dichloroethane										
Magnesium	5.71×10^{-6}	1.84×10^{-6}	1.84×10^{-6}	4.75×10^{3}	6.69×10^{-3}	1.05×10^{0}	1.92×10^{1}	4.21×10^{0}	2.19×10^{3}	1.29×10^{-6}
Manganese	5.21×10^{-7}	4.46×10^{-7}	4.46×10^{-7}	8.12×10^{2}	6.42×10^{-2}	6.38×10^{-3}	1.42×10^{-1}	1.15×10^{-2}	6.47×10^{2}	3.40×10^{-7}
Mercury	1.71×10^{-10}	1.48×10^{-10}	1.48×10^{-10}	2.09×10^{-1}	2.66×10^{-10}	1.99×10^{-6}	1.01×10^{-3}	8.18×10^{-5}	5.50×10^{-2}	7.67×10^{-11}
Silver	1.32×10^{-9}	1.13×10^{-9}	1.13×10^{-9}	1.84×10^{0}					4.80×10^{-1}	5.99×10^{-10}
2,3,7,8-TCDD										
Trichloroethene	7.70×10^{-13}	4.42×10^{-13}	4.42×10^{-13}	7.55×10^{-4}					2.00×10^{-3}	6.43×10^{-13}
Uranium, total	1.16×10^{-8}	1.07×10^{-8}	1.07×10^{-8}	1.16×10^{1}	9.02×10^{-3}	5.61×10^{-3}	5.04×10^{-4}	4.47×10^{-5}	7.20×10^{0}	6.27×10^{-9}

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TABLE H.V-2

OPTION B
EXPOSURE POINT CONCENTRATIONS

COC	On-Air	On-Air	Off-Air	Off-SL	On-GW	Off-GW	On-SED	GMR-SWF	Off-SL	Site Contribution PH
	On-Site Air Max	On-Site Air Avg	Fenceline Off-Site Air	On-Site Soil Avg	Future On-Site GW Well 13	Future Off-Site GW Well 2071	Future On-Site Surface Water	Future GM River Surface Water	Future Off-Site Soil	Future Off-Site Air
	pCi/m^3 mg/m^3	pCi/m^3 mg/m^3	pCi/m^3 mg/m^3	pCi/g mg/kg	pCi/L mg/L	pCi/L mg/L	pCi/L mg/L	pCi/L mg/L	pCi/g mg/kg	pCi/m^3 mg/m^3
Radionuclides										
Radium	7.92×10^{-7}	1.42×10^{-7}	1.42×10^{-7}	3.84×10^{-1}	3.28×10^{-10}		1.45×10^{-3}	7.37×10^{-5}		6.17×10^{-8}
Radon	1.07×10^{1}	1.84×10^{0}	1.84×10^{0}							8.00×10^{-1}
Strontium	7.90×10^{-8}	4.80×10^{-8}	4.80×10^{-8}	1.19×10^{-1}	2.83×10^{-2}	5.36×10^{-6}	1.09×10^{0}	7.43×10^{-2}	1.50×10^{-2}	2.43×10^{-8}
Technetium	1.59×10^{-7}	1.38×10^{-7}	1.38×10^{-7}	2.50×10^{-1}	1.68×10^{1}	4.18×10^{-1}		2.23×10^{0}	2.50×10^{-1}	3.34×10^{-7}
Thorium	8.43×10^{-7}	4.21×10^{-7}	4.21×10^{-7}	6.45×10^{-1}			3.06×10^{-3}	1.23×10^{-3}	2.65×10^{-1}	2.43×10^{-7}
Thorium	8.00×10^{-9}	4.00×10^{-9}	4.00×10^{-9}	3.17×10^{-2}			1.66×10^{-4}	8.44×10^{-6}		1.74×10^{-9}
Uranium					1.33×10^{-1}	8.29×10^{-2}	7.45×10^{-3}	6.61×10^{-4}	2.19×10^{-2}	4.95×10^{-9}
Uranium	3.18×10^{-6}	2.96×10^{-6}	2.96×10^{-6}	2.77×10^{0}	3.01×10^{0}	1.87×10^{0}	1.68×10^{-1}	1.49×10^{-2}	1.32×10^{0}	1.58×10^{-6}
Inorganics/Organics										
Antimony	2.79×10^{-9}	2.02×10^{-9}	2.02×10^{-9}	3.97×10^{-0}			1.04×10^{-4}	8.48×10^{-6}	1.30×10^{0}	1.17×10^{-9}
Aroclor-1254	5.27×10^{-11}	1.58×10^{-11}	1.58×10^{-11}	2.46×10^{-2}					2.20×10^{-2}	1.18×10^{-11}
Aroclor-1260										
Arsenic	3.86×10^{-9}	3.16×10^{-9}	3.16×10^{-9}	5.75×10^{0}	6.28×10^{-7}	2.69×10^{-4}	1.14×10^{-3}	8.72×10^{-5}	3.79×10^{0}	2.23×10^{-9}
Beryllium	4.56×10^{-10}	3.46×10^{-10}	3.46×10^{-10}	6.62×10^{-1}			2.38×10^{-5}	1.87×10^{-6}	4.49×10^{-1}	2.51×10^{-10}
Benzo(a)pyrene	1.28×10^{-11}	1.11×10^{-11}	1.11×10^{-11}	2.00×10^{-2}			1.29×10^{-8}	7.08×10^{-9}	2.00×10^{-2}	9.34×10^{-12}
Cadmium	3.91×10^{-10}	3.03×10^{-10}	3.03×10^{-10}	5.96×10^{-1}					4.90×10^{-1}	2.43×10^{-10}
1,2-Dichloroethane										
Magnesium	5.71×10^{-6}	1.84×10^{-6}	1.84×10^{-6}	4.75×10^{3}	6.69×10^{-3}	1.05×10^{0}	1.92×10^{1}	4.21×10^{0}	2.19×10^{3}	1.29×10^{-6}
Manganese	5.21×10^{-7}	4.46×10^{-7}	4.46×10^{-7}	8.12×10^{2}	6.42×10^{-2}	6.38×10^{-3}	1.42×10^{-1}	1.15×10^{-2}	6.47×10^{2}	3.40×10^{-7}
Mercury	1.71×10^{-10}	1.48×10^{-10}	1.48×10^{-10}	2.09×10^{-1}	2.66×10^{-10}	1.99×10^{-6}	1.01×10^{-3}	8.18×10^{-5}	5.50×10^{-2}	7.67×10^{-11}
Silver	1.32×10^{-9}	1.13×10^{-9}	1.13×10^{-9}	1.84×10^{0}					4.80×10^{-1}	5.99×10^{-10}
2,3,7,8-TCDD										
Trichloroethene	7.70×10^{-13}	4.42×10^{-13}	4.42×10^{-13}	7.55×10^{-4}					2.00×10^{-3}	6.43×10^{-13}
Uranium, total	1.16×10^{-8}	1.07×10^{-8}	1.07×10^{-8}	1.16×10^{1}	9.02×10^{-3}	5.61×10^{-3}	5.04×10^{-4}	4.47×10^{-5}	7.20×10^{0}	6.27×10^{-9}

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Tables H.V-3 through H.V-13 compare potential health effects, calculated using the three options, by receptor and pathway. Risk calculations for Options A and B are presented in Sections H.V.1 and H.V.2, respectively. Risk calculations for the CRARE are presented in Attachment IV.

H.V.1 RISK CHARACTERIZATION USING OPTION A

This section presents the risk and HI estimates for the target and reference receptors by pathway. Table H.V.1-1 summarizes the total HI and ILCR for each receptor. Complete calculation sheets of the risk values can be found in Tables H.V.1-2 through H.V.1-121. The target receptors are presented first, followed by the reference receptors.

H.V.2 RISK CHARACTERIZATION USING OPTION B

This section presents the risk and HI estimates for the target and reference receptors by pathway. Table H.V.2-1 summarizes the total HI and ILCR for each receptor. Complete calculation sheets of the risk values can be found in Tables H.V.2-2 through H.V.2-121. The target receptors are presented first, followed by the reference receptors.

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TABLE H.V-3

SUMMARY OF POTENTIAL HEALTH EFFECTS: UNDEVELOPED PARK USER

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	1.2×10^{-4}	1.2×10^{-4}	NA
Incidental ingestion of residual soils (chemicals)	1.4×10^{-3}	1.4×10^{-3}	1.6×10^{-4}
Dermal contact with residual soils (chemicals)	4.6×10^{-2}	4.6×10^{-2}	8.2×10^{-3}
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	7.5×10^{-4}	7.5×10^{-4}	5.7×10^{-4}
Dermal contact while wading (chemicals)	3.1×10^{-3}	3.1×10^{-3}	1.6×10^{-3}
Noncarcinogenic Pathway Summation =	**5.1×10^{-2}**	**5.1×10^{-2}**	**1.0×10^{-2}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	2.1×10^{-10}	2.1×10^{-10}	6.5×10^{-12}
Inhalation of particulates (radionuclides)	4.3×10^{-8}	7.3×10^{-9}	7.3×10^{-9}
Incidental ingestion of residual soils (chemicals)	4.6×10^{-7}	4.6×10^{-7}	3.2×10^{-8}
Incidental ingestion of residual soils (radionuclides)	6.4×10^{-14}	1.5×10^{-14}	1.5×10^{-14}
Dermal contact with residual soils (chemicals)	6.5×10^{-7}	6.5×10^{-7}	2.2×10^{-7}
Ingestion of drinking water (chemicals)	NA	NA	NA
Ingestion of drinking water (radionuclides)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	4.2×10^{-8}	4.2×10^{-8}	4.2×10^{-8}
Dermal contact while wading (chemicals)	8.0×10^{-9}	9.6×10^{-10}	9.6×10^{-10}
Incidental ingestion while wading (radionuclides)	6.4×10^{-8}	6.4×10^{-8}	6.4×10^{-8}
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of meat (radionuclides)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of dairy products (radionuclides)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (radionuclides)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	1.3×10^{-5}	1.8×10^{-6}	$.8 \times 10^{-6}$
Carcinogenic Pathway Summation =	**1.4×10^{-5}**	**3.0×10^{-6}**	**2.2×10^{-6}**

TABLE H.V-4

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM ADULT

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	6.5×10^{-3}	6.5×10^{-3}	NA
Incidental ingestion of residual soils (chemicals)	5.9×10^{-2}	5.9×10^{-2}	3.3×10^{-3}
Dermal contact with residual soils (chemicals)	1.9×10^{-1}	1.9×10^{-1}	2.1×10^{-2}
Ingestion of meat (chemicals)	2.3×10^{-3}	2.3×10^{-3}	7.3×10^{-6}
Ingestion of dairy products (chemicals)	5.4×10^{-1}	5.4×10^{-1}	2.6×10^{-2}
Ingestion of vegetables and fruit (chemicals)	2.5×10^{0}	2.5×10^{0}	3.9×10^{-2}
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	1.1×10^{-1}	1.1×10^{-1}	4.7×10^{-2}
Dermal contact while bathing (chemicals)	3.3×10^{-2}	3.3×10^{-2}	2.7×10^{-2}
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Noncarcinogenic Pathway Summation =	**3.5×10^{0}**	**3.5×10^{0}**	**1.6×10^{-1}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	1.0×10^{-8}	1.0×10^{-8}	2.0×10^{-10}
Inhalation of particulates (radionuclides)	2.8×10^{-6}	3.1×10^{-7}	3.1×10^{-7}
Incidental ingestion of residual soils (chemicals)	2.2×10^{-5}	2.2×10^{-5}	7.8×10^{-7}
Incidental ingestion of residual soils (radionuclides)	4.1×10^{-6}	1.4×10^{-7}	1.4×10^{-7}
Dermal contact with residual soils (chemicals)	3.1×10^{-6}	3.1×10^{-6}	1.1×10^{-6}
Ingestion of drinking water (chemicals)	1.3×10^{-5}	1.3×10^{-5}	0.0×10^{0}
Ingestion of drinking water (radionuclides)	4.8×10^{-6}	1.9×10^{-6}	1.9×10^{-6}
Dermal contact while bathing (chemicals)	3.9×10^{-7}	3.9×10^{-7}	0.0×10^{0}
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Incidental ingestion while wading (radionuclides)	NA	NA	NA
Ingestion of meat (chemicals)	4.7×10^{-8}	4.7×10^{-8}	1.0×10^{-8}
Ingestion of meat (radionuclides)	3.5×10^{-9}	2.5×10^{-9}	2.5×10^{-9}
Ingestion of dairy products (chemicals)	1.7×10^{-5}	1.7×10^{-5}	1.3×10^{-5}
Ingestion of dairy products (radionuclides)	2.8×10^{-5}	1.2×10^{-5}	1.2×10^{-5}
Ingestion of vegetables and fruit (chemicals)	2.4×10^{-4}	2.4×10^{-4}	3.2×10^{-6}
Ingestion of vegetables and fruit (radionuclides)	5.8×10^{-5}	7.3×10^{-6}	7.3×10^{-6}
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	5.5×10^{-4}	3.0×10^{-6}	3.0×10^{-6}
Carcinogenic Pathway Summation =	**9.5×10^{-4}**	**3.2×10^{-4}**	**4.3×10^{-5}**

TABLE H.V-5

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM CHILD

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	1.8×10^{-2}	1.8×10^{-2}	NA
Incidental ingestion of residual soils (chemicals)	3.1×10^{-1}	3.1×10^{-1}	1.7×10^{-2}
Dermal contact with residual soils (chemicals)	3.1×10^{-1}	3.1×10^{-1}	3.4×10^{-2}
Ingestion of meat (chemicals)	4.3×10^{-3}	4.3×10^{-3}	1.3×10^{-5}
Ingestion of dairy products (chemicals)	5.6×10^{0}	5.6×10^{0}	2.7×10^{-1}
Ingestion of vegetables and fruit (chemicals)	1.0×10^{1}	1.0×10^{1}	1.6×10^{-1}
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	2.7×10^{-1}	2.7×10^{-1}	1.1×10^{-1}
Dermal contact while bathing (chemicals)	1.5×10^{-1}	1.5×10^{-1}	1.3×10^{-1}
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Noncarcinogenic Pathway Summation =	**1.7×10^{1}**	**1.7×10^{1}**	**7.2×10^{-1}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	2.4×10^{-9}	2.4×10^{-9}	4.9×10^{-11}
Inhalation of particulates (radionuclides)	1.4×10^{-7}	1.6×10^{-8}	1.6×10^{-8}
Incidental ingestion of residual soils (chemicals)	9.7×10^{-6}	9.7×10^{-6}	3.5×10^{-7}
Incidental ingestion of residual soils (radionuclides)	3.9×10^{-7}	1.3×10^{-8}	1.3×10^{-8}
Dermal contact with residual soils (chemicals)	4.4×10^{-7}	4.4×10^{-7}	1.5×10^{-7}
Ingestion of drinking water (chemicals)	2.6×10^{-6}	2.6×10^{-6}	0.0×10^{0}
Ingestion of drinking water (radionuclides)	2.1×10^{-7}	8.2×10^{-8}	8.2×10^{-8}
Dermal contact while bathing (chemicals)	1.6×10^{-7}	1.6×10^{-7}	0.0×10^{0}
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Incidental ingestion while wading (radionuclides)	NA	NA	NA
Ingestion of meat (chemicals)	7.3×10^{-9}	7.3×10^{-9}	1.6×10^{-9}
Ingestion of meat (radionuclides)	1.2×10^{-10}	8.2×10^{-11}	8.2×10^{-11}
Ingestion of dairy products (chemicals)	1.6×10^{-5}	1.6×10^{-5}	1.2×10^{-5}
Ingestion of dairy products (radionuclides)	5.4×10^{-6}	2.4×10^{-6}	2.4×10^{-6}
Ingestion of vegetables and fruit (chemicals)	8.4×10^{-5}	8.4×10^{-5}	1.1×10^{-6}
Ingestion of vegetables and fruit (radionuclides)	4.3×10^{-6}	5.4×10^{-7}	5.4×10^{-7}
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	4.1×10^{-5}	2.3×10^{-7}	2.3×10^{-7}
Carcinogenic Pathway Summation =	**1.6×10^{-4}**	**1.2×10^{-4}**	**1.7×10^{-5}**

TABLE H.V-6

SUMMARY OF POTENTIAL HEALTH EFFECTS: ON-PROPERTY RESIDENT FARM ADULT

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	1.0×10^{-2}	1.0×10^{-2}	1.1×10^{-2}
Incidental ingestion of residual soils (chemicals)	1.0×10^{-1}	1.0×10^{-1}	1.1×10^{-2}
Dermal contact with residual soils (chemicals)	3.0×10^{-1}	3.0×10^{-1}	5.4×10^{-2}
Ingestion of meat (chemicals)	8.5×10^{-3}	8.5×10^{-3}	8.9×10^{-5}
Ingestion of dairy products (chemicals)	1.3×10^{0}	1.3×10^{0}	2.6×10^{-1}
Ingestion of vegetables and fruit (chemicals)	4.9×10^{0}	4.9×10^{0}	4.7×10^{-1}
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	4.3×10^{-1}	4.3×10^{-1}	1.6×10^{-1}
Dermal contact while bathing (chemicals)	5.9×10^{-2}	5.9×10^{-2}	4.8×10^{-2}
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Noncarcinogenic Pathway Summation =	**7.1×10^{0}**	**7.1×10^{0}**	**1.0×10^{0}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	1.8×10^{-8}	1.8×10^{-8}	1.6×10^{-9}
Inhalation of particulates (radionuclides)	8.0×10^{-6}	3.9×10^{-6}	3.9×10^{-6}
Incidental ingestion of residual soils (chemicals)	3.3×10^{-5}	3.3×10^{-5}	2.3×10^{-6}
Incidental ingestion of residual soils (radionuclides)	6.9×10^{-6}	1.6×10^{-6}	1.6×10^{-6}
Dermal contact with residual soils (chemicals)	4.3×10^{-6}	4.3×10^{-6}	1.4×10^{-6}
Ingestion of drinking water (chemicals)	3.0×10^{-8}	3.0×10^{-8}	0.0×10^{0}
Ingestion of drinking water (radionuclides)	3.0×10^{-5}	4.2×10^{-6}	4.2×10^{-6}
Dermal contact while bathing (chemicals)	9.1×10^{-10}	9.1×10^{-10}	0.0×10^{0}
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Incidental ingestion while wading (radionuclides)	NA	NA	NA
Ingestion of meat (chemicals)	6.6×10^{-8}	6.6×10^{-8}	1.3×10^{-8}
Ingestion of meat (radionuclides)	4.1×10^{-9}	2.9×10^{-9}	2.9×10^{-9}
Ingestion of dairy products (chemicals)	2.0×10^{-5}	2.0×10^{-5}	1.4×10^{-5}
Ingestion of dairy products (radionuclides)	3.6×10^{-5}	1.9×10^{-5}	1.9×10^{-5}
Ingestion of vegetables and fruit (chemicals)	3.6×10^{-4}	3.6×10^{-4}	1.7×10^{-5}
Ingestion of vegetables and fruit (radionuclides)	8.8×10^{-5}	2.9×10^{-5}	2.9×10^{-5}
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	8.0×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
Carcinogenic Pathway Summation =	**1.4×10^{-3}**	**5.9×10^{-4}**	**2.1×10^{-4}**

000204

TABLE H.V-7

SUMMARY OF POTENTIAL HEALTH EFFECTS: ON-PROPERTY RESIDENT FARM CHILD

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	2.8×10^{-2}	2.8×10^{-2}	5.9×10^{-2}
Incidental ingestion of residual soils (chemicals)	5.2×10^{-1}	5.2×10^{-1}	5.9×10^{-2}
Dermal contact with residual soils (chemicals)	4.9×10^{-1}	4.9×10^{-1}	8.7×10^{-2}
Ingestion of meat (chemicals)	1.6×10^{-2}	1.6×10^{-2}	1.6×10^{-4}
Ingestion of dairy products (chemicals)	1.4×10^{1}	1.4×10^{1}	2.7×10^{0}
Ingestion of vegetables and fruit (chemicals)	2.0×10^{1}	2.0×10^{1}	1.9×10^{0}
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	1.0×10^{0}	1.0×10^{0}	3.7×10^{-1}
Dermal contact while bathing (chemicals)	2.8×10^{-1}	2.8×10^{-1}	2.2×10^{-1}
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Noncarcinogenic Pathway Summation =	**3.6×10^{1}**	**3.6×10^{1}**	**5.4×10^{0}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	4.2×10^{-9}	4.2×10^{-9}	3.8×10^{-10}
Inhalation of particulates (radionuclides)	4.1×10^{-7}	2.0×10^{-7}	2.0×10^{-7}
Incidental ingestion of residual soils (chemicals)	1.5×10^{-5}	1.5×10^{-5}	1.0×10^{-6}
Incidental ingestion of residual soils (radionuclides)	6.9×10^{-7}	1.6×10^{-7}	1.6×10^{-7}
Dermal contact with residual soils (chemicals)	5.9×10^{-7}	5.9×10^{-7}	2.0×10^{-7}
Ingestion of drinking water (chemicals)	6.0×10^{-9}	6.0×10^{-9}	0.0×10^{0}
Ingestion of drinking water (radionuclides)	1.3×10^{-6}	1.8×10^{-7}	1.8×10^{-7}
Dermal contact while bathing (chemicals)	3.6×10^{-10}	3.6×10^{-10}	0.0×10^{0}
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Incidental ingestion while wading (radionuclides)	NA	NA	NA
Ingestion of meat (chemicals)	1.0×10^{-8}	1.0×10^{-8}	2.0×10^{-9}
Ingestion of meat (radionuclides)	1.4×10^{-10}	9.8×10^{-11}	9.8×10^{-11}
Ingestion of dairy products (chemicals)	1.8×10^{-5}	1.8×10^{-5}	1.3×10^{-5}
Ingestion of dairy products (radionuclides)	6.9×10^{-6}	3.6×10^{-6}	3.6×10^{-6}
Ingestion of vegetables and fruit (chemicals)	1.3×10^{-4}	1.3×10^{-4}	5.9×10^{-6}
Ingestion of vegetables and fruit (radionuclides)	6.6×10^{-6}	2.1×10^{-6}	2.1×10^{-6}
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	6.0×10^{-5}	8.4×10^{-6}	8.4×10^{-6}
Carcinogenic Pathway Summation =	**2.4×10^{-4}**	**1.7×10^{-4}**	**3.5×10^{-5}**

TABLE H.V-8

SUMMARY OF POTENTIAL HEALTH EFFECTS: MILK AND MEAT CONSUMER

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	NA	NA	NA
Incidental ingestion of residual soils (chemicals)	NA	NA	NA
Dermal contact with residual soils (chemicals)	NA	NA	NA
Ingestion of meat (chemicals)	8.5×10^{-3}	8.5×10^{-3}	8.9×10^{-5}
Ingestion of dairy products (chemicals)	1.3×10^{0}	1.3×10^{0}	2.6×10^{-1}
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Noncarcinogenic Pathway Summation =	**1.3×10^{0}**	**1.3×10^{0}**	**2.6×10^{-1}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	NA	NA	NA
Inhalation of particulates (radionuclides)	NA	NA	NA
Incidental ingestion of residual soils (chemicals)	NA	NA	NA
Incidental ingestion of residual soils (radionuclides)	NA	NA	NA
Dermal contact with residual soils (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	NA	NA	NA
Ingestion of drinking water (radionuclides)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Incidental ingestion while wading (radionuclides)	NA	NA	NA
Ingestion of meat (chemicals)	6.6×10^{-8}	6.6×10^{-8}	1.3×10^{-8}
Ingestion of meat (radionuclides)	4.1×10^{-9}	2.9×10^{-9}	2.9×10^{-9}
Ingestion of dairy products (chemicals)	2.0×10^{-5}	2.0×10^{-5}	1.4×10^{-5}
Ingestion of dairy products (radionuclides)	3.6×10^{-5}	1.9×10^{-5}	1.9×10^{-5}
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (radionuclides)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	NA	NA	NA
Carcinogenic Pathway Summation =	**5.6×10^{-5}**	**3.9×10^{-5}**	**3.3×10^{-5}**

000206

TABLE H.V-9

SUMMARY OF POTENTIAL HEALTH EFFECTS: COMMERCIAL/INDUSTRIAL USER

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	6.1×10^{-3}	6.1×10^{-3}	NA
Incidental ingestion of residual soils (chemicals)	4.0×10^{-2}	4.0×10^{-2}	4.5×10^{-3}
Dermal contact with residual soils (chemicals)	2.2×10^{-1}	2.2×10^{-1}	3.8×10^{-2}
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Noncarcinogenic Pathway Summation =	**2.6×10^{-1}**	**2.6×10^{-1}**	**4.3×10^{-2}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	3.7×10^{-9}	3.7×10^{-9}	1.1×10^{-10}
Inhalation of particulates (radionuclides)	1.1×10^{-6}	1.8×10^{-7}	1.8×10^{-7}
Incidental ingestion of residual soils (chemicals)	4.6×10^{-6}	4.6×10^{-6}	3.3×10^{-7}
Incidental ingestion of residual soils (radionuclides)	9.7×10^{-7}	2.3×10^{-7}	2.3×10^{-7}
Dermal contact with residual soils (chemicals)	1.1×10^{-6}	1.1×10^{-6}	3.7×10^{-7}
Ingestion of drinking water (chemicals)	NA	NA	NA
Ingestion of drinking water (radionuclides)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	NA	NA	NA
Dermal contact while wading (chemicals)	NA	NA	NA
Incidental ingestion while wading (radionuclides)	NA	NA	NA
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of meat (radionuclides)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of dairy products (radionuclides)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (radionuclides)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	2.0×10^{-4}	2.8×10^{-5}	2.8×10^{-5}
Carcinogenic Pathway Summation =	**2.0×10^{-4}**	**3.4×10^{-5}**	**2.9×10^{-5}**

TABLE H.V-10

SUMMARY OF POTENTIAL HEALTH EFFECTS: DEVELOPED PARK USER

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	3.3×10^{-4}	3.3×10^{-4}	0.0×10^{0}
Incidental ingestion of residual soils (chemicals)	4.3×10^{-3}	4.3×10^{-3}	4.8×10^{-4}
Dermal contact with residual soils (chemicals)	5.1×10^{-2}	5.1×10^{-2}	9.1×10^{-3}
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	7.5×10^{-4}	7.5×10^{-4}	5.7×10^{-4}
Dermal contact while wading (chemicals)	3.1×10^{-3}	3.1×10^{-3}	1.6×10^{-3}
Noncarcinogenic Pathway Summation =	**6.0×10^{-2}**	**6.0×10^{-2}**	**1.2×10^{-2}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	5.5×10^{-10}	5.5×10^{-10}	1.7×10^{-11}
Inhalation of particulates (radionuclides)	9.6×10^{-8}	1.6×10^{-8}	1.6×10^{-8}
Incidental ingestion of residual soils (chemicals)	1.4×10^{-6}	1.4×10^{-6}	9.7×10^{-8}
Incidental ingestion of residual soils (radionuclides)	1.5×10^{-13}	3.6×10^{-14}	3.6×10^{-14}
Dermal contact with residual soils (chemicals)	7.3×10^{-7}	7.3×10^{-7}	2.4×10^{-7}
Ingestion of drinking water (chemicals)	NA	NA	NA
Ingestion of drinking water (radionuclides)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	4.2×10^{-8}	4.2×10^{-8}	4.2×10^{-8}
Dermal contact while wading (chemicals)	8.0×10^{-9}	9.6×10^{-10}	9.6×10^{-10}
Incidental ingestion while wading (radionuclides)	6.4×10^{-8}	6.4×10^{-8}	6.4×10^{-8}
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of meat (radionuclides)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of dairy products (radionuclides)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (radionuclides)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	3.1×10^{-5}	4.3×10^{-6}	4.3×10^{-6}
Carcinogenic Pathway Summation =	**3.3×10^{-5}**	**6.5×10^{-6}**	**4.8×10^{-6}**

TABLE H.V-11

SUMMARY OF POTENTIAL HEALTH EFFECTS: WILDLIFE RESERVE USER

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	9.5×10^{-5}	9.5×10^{-5}	0.0×10^{0}
Incidental ingestion of residual soils (chemicals)	1.1×10^{-3}	1.1×10^{-3}	1.2×10^{-4}
Dermal contact with residual soils (chemicals)	3.9×10^{-2}	3.9×10^{-2}	6.9×10^{-3}
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	7.5×10^{-4}	7.5×10^{-4}	5.7×10^{-4}
Dermal contact while wading (chemicals)	3.1×10^{-3}	3.1×10^{-3}	1.6×10^{-3}
Noncarcinogenic Pathway Summation =	**4.4×10^{-2}**	**4.4×10^{-2}**	**9.1×10^{-3}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	1.6×10^{-10}	1.6×10^{-10}	5.0×10^{-12}
Inhalation of particulates (radionuclides)	3.8×10^{-8}	6.4×10^{-9}	6.4×10^{-9}
Incidental ingestion of residual soils (chemicals)	3.4×10^{-7}	3.4×10^{-7}	2.4×10^{-8}
Incidental ingestion of residual soils (radionuclides)	5.6×10^{-14}	1.3×10^{-14}	1.3×10^{-14}
Dermal contact with residual soils (chemicals)	5.5×10^{-7}	5.5×10^{-7}	1.8×10^{-7}
Ingestion of drinking water (chemicals)	NA	NA	NA
Ingestion of drinking water (radionuclides)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	4.2×10^{-8}	4.2×10^{-8}	4.2×10^{-8}
Dermal contact while wading (chemicals)	8.0×10^{-9}	9.6×10^{-10}	9.6×10^{-10}
Incidental ingestion while wading (radionuclides)	6.4×10^{-8}	6.4×10^{-8}	6.4×10^{-8}
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of meat (radionuclides)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of dairy products (radionuclides)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (radionuclides)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	1.1×10^{-5}	1.6×10^{-6}	1.6×10^{-6}
Carcinogenic Pathway Summation =	**1.2×10^{-5}**	**2.6×10^{-6}**	**1.9×10^{-6}**

TABLE H.V-12

SUMMARY OF POTENTIAL HEALTH EFFECTS: EXPANDED TRESPASSER

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	3.0×10^{-5}	3.0×10^{-5}	0.0×10^{0}
Incidental ingestion of residual soils (chemicals)	1.6×10^{-3}	1.6×10^{-3}	1.8×10^{-4}
Dermal contact with residual soils (chemicals)	5.6×10^{-2}	5.6×10^{-2}	9.9×10^{-3}
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	1.2×10^{-3}	1.2×10^{-3}	9.1×10^{-4}
Dermal contact while wading (chemicals)	4.9×10^{-3}	4.9×10^{-3}	2.5×10^{-3}
Noncarcinogenic Pathway Summation =	**6.4×10^{-2}**	**6.4×10^{-2}**	**1.4×10^{-2}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	1.4×10^{-10}	1.4×10^{-10}	4.2×10^{-12}
Inhalation of particulates (radionuclides)	2.7×10^{-8}	4.6×10^{-9}	4.6×10^{-9}
Incidental ingestion of residual soils (chemicals)	3.2×10^{-7}	3.2×10^{-7}	2.2×10^{-8}
Incidental ingestion of residual soils (radionuclides)	5.1×10^{-8}	1.2×10^{-8}	1.2×10^{-8}
Dermal contact with residual soils (chemicals)	5.0×10^{-7}	5.0×10^{-7}	1.7×10^{-7}
Ingestion of drinking water (chemicals)	NA	NA	NA
Ingestion of drinking water (radionuclides)	NA	NA	NA
Dermal contact while bathing (chemicals)	NA	NA	NA
Incidental ingestion while wading (chemicals)	4.2×10^{-8}	4.2×10^{-8}	4.2×10^{-8}
Dermal contact while wading (chemicals)	8.0×10^{-9}	9.6×10^{-10}	9.6×10^{-10}
Incidental ingestion while wading (radionuclides)	6.4×10^{-8}	6.4×10^{-8}	6.4×10^{-8}
Ingestion of meat (chemicals)	NA	NA	NA
Ingestion of meat (radionuclides)	NA	NA	NA
Ingestion of dairy products (chemicals)	NA	NA	NA
Ingestion of dairy products (radionuclides)	NA	NA	NA
Ingestion of vegetables and fruit (chemicals)	NA	NA	NA
Ingestion of vegetables and fruit (radionuclides)	NA	NA	NA
Ingestion of fish (chemicals)	NA	NA	NA
Ingestion of fish (radionuclides)	NA	NA	NA
Direct radiation	8.3×10^{-6}	1.2×10^{-6}	1.2×10^{-6}
Carcinogenic Pathway Summation =	**9.3×10^{-6}**	**2.1×10^{-6}**	**1.5×10^{-6}**

TABLE H.V-13

SUMMARY OF POTENTIAL HEALTH EFFECTS: GREAT MIAMI RIVER USER

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	NA	NA	NA
Incidental ingestion of residual soils (chemicals)	NA	NA	NA
Dermal contact with residual soils (chemicals)	NA	NA	NA
Ingestion of meat (chemicals)	3.7×10^{-6}	3.7×10^{-6}	3.5×10^{-6}
Ingestion of dairy products (chemicals)	4.7×10^{-4}	4.7×10^{-4}	3.1×10^{-5}
Ingestion of vegetables and fruit (chemicals)	4.6×10^{-3}	4.6×10^{-3}	1.2×10^{-3}
Ingestion of fish (chemicals)	3.9×10^{-1}	3.9×10^{-1}	3.9×10^{-1}
Ingestion of drinking water (chemicals)	3.1×10^{-2}	3.1×10^{-2}	8.1×10^{-3}
Dermal contact while bathing (chemicals)	1.1×10^{-2}	1.1×10^{-2}	1.5×10^{-3}
Incidental ingestion while wading (chemicals)	1.5×10^{-9}	1.5×10^{-9}	7.8×10^{-11}
Dermal contact while wading (chemicals)	1.1×10^{-8}	1.1×10^{-8}	5.1×10^{-10}
Noncarcinogenic Pathway Summation =	**4.4×10^{-1}**	**4.4×10^{-1}**	**3.9×10^{-1}**

Exposure Pathway	Option A	Option B	CRARE
Inhalation of particulates (chemicals)	NA	NA	NA
Inhalation of particulates (radionuclides)	NA	NA	NA
Incidental ingestion of residual soils (chemicals)	NA	NA	NA
Incidental ingestion of residual soils (radionuclides)	NA	NA	NA
Dermal contact with residual soils (chemicals)	NA	NA	NA
Ingestion of drinking water (chemicals)	4.4×10^{-6}	4.4×10^{-6}	2.2×10^{-7}
Ingestion of drinking water (radionuclides)	1.7×10^{-5}	2.9×10^{-7}	2.9×10^{-7}
Dermal contact while bathing (chemicals)	1.3×10^{-7}	1.3×10^{-7}	6.3×10^{-9}
Incidental ingestion while wading (chemicals)	1.5×10^{-9}	1.5×10^{-9}	7.8×10^{-11}
Dermal contact while wading (chemicals)	1.1×10^{-8}	1.1×10^{-8}	5.1×10^{-10}
Incidental ingestion while wading (radionuclides)	2.6×10^{-9}	4.4×10^{-11}	4.4×10^{-11}
Ingestion of meat (chemicals)	1.6×10^{-11}	1.6×10^{-11}	5.0×10^{-13}
Ingestion of meat (radionuclides)	1.0×10^{-11}	2.4×10^{-12}	2.4×10^{-12}
Ingestion of dairy products (chemicals)	2.4×10^{-9}	2.4×10^{-9}	1.3×10^{-10}
Ingestion of dairy products (radionuclides)	8.3×10^{-8}	1.5×10^{-8}	1.5×10^{-8}
Ingestion of vegetables and fruit (chemicals)	6.6×10^{-7}	6.6×10^{-7}	3.3×10^{-8}
Ingestion of vegetables and fruit (radionuclides)	2.6×10^{-6}	4.5×10^{-8}	4.5×10^{-8}
Ingestion of fish (chemicals)	9.0×10^{-7}	9.0×10^{-7}	1.6×10^{-7}
Ingestion of fish (radionuclides)	1.1×10^{-12}	2.5×10^{-13}	2.5×10^{-13}
Direct radiation	NA	NA	NA
Carcinogenic Pathway Summation =	**2.6×10^{-5}**	**6.5×10^{-6}**	**7.7×10^{-7}**

ATTACHMENT H.V
BACKGROUND CONTRIBUTIONS TO RISK
H.V-1 RISK CHARACTERIZATION USING OPTION A

TABLE H.V.1-1

SUMMARY OF OPTION A HEALTH EFFECTS: FOR ALL RECEPTORS

Target Receptor	Risk	HI
Undeveloped	1.4E-05	5.1E-02
Off-Property Resident Farm		
Adult	9.5E-04	3.5E+00
Child	1.6E-04	1.7E+01
Reference Receptor	**Risk**	**HI**
On-Property Resident Farm		
Adult	1.4E-03	7.1E+00
Child	2.4E-04	3.6E+01
Commercial/Industrial User	2.0E-04	2.6E-01
Developed Park User	3.3E-05	6.0E-02
Wildlife Reserve User	1.2E-05	4.4E-02
Expanded Trespasser	9.3E-06	6.4E-02
Meat and Milk Consumer	5.6E-05	1.3E+00
Great Miami River User	2.6E-05	4.4E-01

Table H.V.1–2
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	years
BWa	Body weight (adult)	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	days
ATa	Average time for non–carcinogens (adult)	2190	4380	13870	5110	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units
antimony	2.0E–09	mg/m^3
arodor–1254	1.6E–11	mg/m^3
arodor–1260		mg/m^3
arsenic	3.2E–09	mg/m^3
beryllium	3.5E–10	mg/m^3
benzo(a)pyrene	1.1E–11	mg/m^3
cadmium	3.0E–10	mg/m^3
1,2–dichloroethane		mg/m^3
magnesium	1.8E–06	mg/m^3
manganese	4.5E–07	mg/m^3
mercury	1.5E–10	mg/m^3
silver	1.1E–09	mg/m^3
2,3,7,8–tcdd		mg/m^3
trichloroethene	4.4E–13	mg/m^3
uranium–total	1.1E–08	mg/m^3
		mg/m^3

Compound	Concentration	Units
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3

References

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Table H.V.1–2 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	8.0E–12	NA	NA
aroclor–1254	6.3E–14	NA	NA
aroclor–1260	NA	NA	NA
arsenic	1.3E–11	NA	NA
beryllium	1.4E–12	NA	NA
benzo(a)pyrene	4.4E–14	NA	NA
cadmium	1.2E–12	NA	NA
1,2–dichloroethane	NA	2.9E–03	
magnesium	7.3E–09	NA	NA
manganese	1.8E–09	1.4E–05	1.2E–04
mercury	5.9E–13	8.6E–05	6.9E–09
silver	4.5E–12	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.8E–15	NA	NA
uranium–total	4.3E–11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			1.2E–04

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	8.0E–12	NA	NA
aroclor–1254	6.3E–14	NA	NA
aroclor–1260	NA	NA	NA
arsenic	1.3E–11	1.5E+01	1.9E–10
beryllium	1.4E–12	8.4E+00	1.2E–11
benzo(a)pyrene	4.4E–14	6.1E+00	2.7E–13
cadmium	1.2E–12	6.3E+00	7.6E–12
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	7.3E–09	NA	NA
manganese	1.8E–09	NA	NA
mercury	5.9E–13	NA	NA
silver	4.5E–12	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.8E–15	6.0E–03	1.1E–17
uranium–total	4.3E–11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			2.1E–10

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Table H.V.1–3
Summary of Risk Quantitation (radionuclides)
Target Receptor: Undeveloped Park User
Via Inhalation of Gases and Particulates

Intake Equation = CA X EF X ED X IR X ET

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ED	Exposure duration	6	12	38	14	years
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	40	104	40	26	days/year
CA	Concentration of radionuclides in air	csv	csv	csv	csv	

Ra_{226+8d}	8.2E–07	pCi/m^3	pCi/m^3
Rn_{222}	1.1E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	1.9E–07	pCi/m^3	pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3	pCi/m^3
Th_{230}	1.3E–06	pCi/m^3	pCi/m^3
$Th_{232+10d}$	6.0E–07	pCi/m^3	pCi/m^3
$U_{235/236}$	4.7E–08	pCi/m^3	pCi/m^3
U_{238+2d}	3.6E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	4.2E–03	7.0E–09	2.9E–11
Rn_{222}	5.8E+04	7.3E–13	4.2E–08
Sr_{90+1d}	9.5E–04	6.2E–11	5.9E–14
Tc_{99}	7.0E–04	8.3E–12	5.8E–15
Th_{230}	6.4E–03	2.9E–08	1.8E–10
$Th_{232+10d}$	3.1E–03	1.1E–07	3.4E–10
$U_{235/236}$	2.4E–04	2.5E–08	5.9E–12
U_{238+2d}	1.8E–02	2.4E–08	4.4E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		4.3E–08

Table II.V.1-4
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Incidental Ingestion of Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E-06	1E-06	1E-06	1E-06	kg/mg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non-carcinogens	2190	4380	13870	5110	day
BW	Body weight	15	43	70	70	kg
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units
antimony	4.0E+00	mg/kg
aroclor-1254	2.5E-02	mg/kg
aroclor-1260		mg/kg
arsenic	5.8E+00	mg/kg
beryllium	6.6E-01	mg/kg
benzo(a)pyrene	2.0E-02	mg/kg
cadmium	6.0E-01	mg/kg
1,2-dichloroethane		mg/kg
magnesium	4.8E+03	mg/kg
manganese	8.1E+02	mg/kg
mercury	2.1E-01	mg/kg
silver	1.8E+00	mg/kg
2,3,7,8-tcdd		mg/kg
trichloroethene	7.6E-04	mg/kg
uranium-total	1.2E+01	mg/kg
		mg/kg

Compound	Concentration	Units
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg

References

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Table H.V.1-4 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.4E-07	4.0E-04	3.4E-04
aroclor-1254	8.5E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.0E-07	3.0E-04	6.6E-04
beryllium	2.3E-08	5.0E-03	4.6E-06
benzo(a)pyrene	6.9E-10	NA	NA
cadmium	2.1E-08	1.0E-03	2.1E-05
1,2-dichloroethane	NA	NA	NA
magnesium	1.6E-04	9.7E+00	1.7E-05
manganese	2.8E-05	1.4E-01	2.0E-04
mercury	7.2E-09	3.0E-04	2.4E-05
silver	6.4E-08	5.0E-03	1.3E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.6E-11	6.0E-03	4.3E-09
uranium-total	4.0E-07	3.0E-03	1.3E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.4E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.4E-07	NA	NA
aroclor-1254	8.5E-10	7.7E+00	6.5E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	2.0E-07	1.8E+00	3.5E-07
beryllium	2.3E-08	4.3E+00	9.8E-08
benzo(a)pyrene	6.9E-10	7.3E+00	5.0E-09
cadmium	2.1E-08	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.6E-04	NA	NA
manganese	2.8E-05	NA	NA
mercury	7.2E-09	NA	NA
silver	6.4E-08	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.6E-11	1.1E-02	2.9E-13
uranium-total	4.0E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.6E-07

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Table H.V.1–5
Summary of Risk Quantitation (radionuclides)
Target Receptor: Undeveloped Park User
Via Incidental Ingestion of Soil/Sediment

Intake Equation = CS X EF X ED X FI X IR

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	year
FI	Fractional Intake	1	1	1	1	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Ra_{226+8d}	1.6E–03	pCi/mg		pCi/mg
Rn_{222}		pCi/mg		pCi/mg
Sr_{90+1d}	3.7E–04	pCi/mg		pCi/mg
Tc_{99}	2.5E–04	pCi/mg		pCi/mg
Th_{230}	2.1E–03	pCi/mg		pCi/mg
$Th_{232+10d}$	1.1E–03	pCi/mg		pCi/mg
$U_{235/236}$	7.1E–05	pCi/mg		pCi/mg
U_{238+2d}	3.9E–03	pCi/mg		pCi/mg
		pCi/mg		pCi/mg
		pCi/mg		pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	6.6E–05	7.8E–10	5.1E–14
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.5E–05	3.6E–11	5.5E–16
Tc_{99}	1.0E–05	1.3E–12	1.3E–17
Th_{230}	8.8E–05	1.3E–11	1.1E–15
$Th_{232+10d}$	4.6E–05	1.7E–10	7.7E–15
$U_{235/236}$	2.9E–06	1.6E–11	4.6E–17
U_{238+2d}	1.6E–04	2.0E–11	3.2E–15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 6.4E–14

Table H.V.1–6
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact with Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		child	youth	adult	senoir adult
SA	Surface area of exposed skin	2000	4138	5750	5750 cm^2/day
AF	Absorbtion factor	csv	csv	csv	csv (unitless)
EF	Exposure frequency	40	104	40	26 days/year
ED	Exposure duration	6	12	38	14 year
CF	Conversion factor	1E–06	1.000E–06	1E–06	1E–06 kg/mg
BW	Body weight	15	43	70	70 kg
AT	Average time for carcinogens	25550	25550	25550	25550 day
AT	Average time for non–carcinogens	2190	4380	13870	5110 day
ABS	Absorbtion factor	csv	csv	csv	csv (unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv

Chemical Concentrations

Compound	ABS	Concentration	Units
antimony	1.0E–02	4.0E+00	mg/kg
arodor–1254	6.0E–02	2.5E–02	mg/kg
arodor–1260	6.0E–02		mg/kg
arsenic	1.0E–03	5.8E+00	mg/kg
beryllium	1.0E–02	6.6E–01	mg/kg
benzo(a)pyrene	3.0E–01	2.0E–02	mg/kg
cadmium	1.0E–02	6.0E–01	mg/kg
1,2–dichloroethane	3.0E–01		mg/kg
magnesium	1.0E–02	4.8E+03	mg/kg
manganese	1.0E–02	8.1E+02	mg/kg
mercury	5.0E–02	2.1E–01	mg/kg
silver	1.0E–02	1.8E+00	mg/kg
2,3,7,8–tcdd	3.0E–02		mg/kg
trichloroethene	3.0E–01	7.6E–04	mg/kg
uranium–total	1.0E–02	1.2E+01	mg/kg
	NA		mg/kg

Compound	ABS	Concentration	Units
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg

References

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Table H.V.1-6 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.8E-07	6.0E-05	7.9E-03
aroclor-1254	1.8E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.9E-08	2.9E-04	2.4E-04
beryllium	8.0E-08	5.0E-03	1.6E-05
benzo(a)pyrene	7.2E-08	NA	NA
cadmium	7.2E-08	5.0E-05	1.4E-03
1,2-dichloroethane	NA	NA	NA
magnesium	5.7E-04	4.9E-01	1.2E-03
manganese	9.8E-05	4.2E-03	2.3E-02
mercury	1.3E-07	4.5E-05	2.8E-03
silver	2.2E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.7E-09	5.9E-03	4.6E-07
uranium-total	1.4E-06	1.5E-04	9.3E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.6E-02

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	4.8E-07	NA	NA
aroclor-1254	1.8E-08	1.0E+01	1.8E-07
aroclor-1260	NA	1.0E+01	NA
arsenic	6.9E-08	1.8E+00	1.3E-07
beryllium	8.0E-08	4.3E+00	3.4E-07
benzo(a)pyrene	7.2E-08	NA	NA
cadmium	7.2E-08	NA	NA
1,2-dichloroethane	NA	1.0E-01	NA
magnesium	5.7E-04	NA	NA
manganese	9.8E-05	NA	NA
mercury	1.3E-07	NA	NA
silver	2.2E-07	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
trichloroethene	2.7E-09	1.1E-02	3.1E-11
uranium-total	1.4E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		6.5E-07

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Table H.V.1-7
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Ingestion While Wading

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non-carcinogens	2190	4380	13870	5110	days
CS	Concentration of chemicals in surface water	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E-04	mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	1.14E-03	mg/l			mg/l
beryllium	2.38E-05	mg/l			mg/l
benzo(a)pyrene	1.29E-08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	1.92E+01	mg/l			mg/l
manganese	1.42E-01	mg/l			mg/l
mercury	1.01E-03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	5.04E-04	mg/l			mg/l
		mg/l			

References

Table H.V.1–7 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	2.07E–09	4.00E–04	5.17E–06
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.27E–08	3.00E–04	7.55E–05
beryllium	4.73E–10	5.00E–03	9.46E–08
benzo(a)pyrene	2.56E–13	NA	NA
cadmium	NA	1.00E–03	NA
1,2–dichloroethane	NA	NA	NA
magnesium	3.82E–04	9.70E+00	3.93E–05
manganese	2.82E–06	5.00E–03	5.65E–04
mercury	2.01E–08	3.00E–04	6.69E–05
silver	NA	5.00E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	6.00E–03	NA
uranium–total	1.00E–08	3.00E–03	3.34E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		7.55E–04

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	2.07E–09	NA	NA
aroclor–1254		7.70E+00	NA
aroclor–1260		7.70E+00	NA
arsenic	2.27E–08	1.75E+00	3.97E–08
beryllium	4.73E–10	4.30E+00	2.03E–09
benzo(a)pyrene	2.56E–13	7.30E+00	1.87E–12
cadmium	NA	NA	NA
1,2–dichloroethane		9.10E–02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd		1.50E+05	NA
trichloroethene		1.10E–02	NA
uranium–total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.17E–08

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Table H.V.1–8
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact While Wading

Intake Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
SA	Skin surface area		5130			cm^2
DA	chemicals specific dermal absorbed dose	csv	csv	csv	csv	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E–09	mg/cm^2–day			mg/cm^2–day
arodor–1254		mg/cm^2–day			mg/cm^2–day
arodor–1260		mg/cm^2–day			mg/cm^2–day
arsenic	1.14E–08	mg/cm^2–day			mg/cm^2–day
beryllium	2.38E–10	mg/cm^2–day			mg/cm^2–day
benzo(a)pyrene	7.29E–10	mg/cm^2–day			mg/cm^2–day
cadmium		mg/cm^2–day			mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day			mg/cm^2–day
magnesium	1.92E–04	mg/cm^2–day			mg/cm^2–day
manganese	1.42E–06	mg/cm^2–day			mg/cm^2–day
mercury	1.01E–08	mg/cm^2–day			mg/cm^2–day
silver		mg/cm^2–day			mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day			mg/cm^2–day
trichloroethene		mg/cm^2–day			mg/cm^2–day
uranium–total	5.04E–09	mg/cm^2–day			mg/cm^2–day
		mg/cm^2–day			

References

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Table H.V.1–8 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact While Wading

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	3.03E–09	6.00E–05	5.05E–05
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	3.32E–08	2.85E–04	1.17E–04
beryllium	6.93E–10	5.00E–03	1.39E–07
benzo(a)pyrene	2.12E–09	NA	NA
cadmium	NA	5.00E–05	NA
1,2–dichloroethane	NA	NA	NA
magnesium	5.59E–04	4.85E–01	1.15E–03
manganese	4.14E–06	4.20E–03	9.85E–04
mercury	2.94E–08	4.50E–05	6.54E–04
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	5.88E–03	NA
uranium–total	1.47E–08	1.50E–04	9.79E–05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.06E–03

Compound	TLCR Calculation CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	3.03E–09	NA	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
arsenic	3.32E–08	1.84E+00	6.12E–08
beryllium	6.93E–10	4.30E+00	2.98E–09
benzo(a)pyrene	2.12E–09	NA	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	1.01E–01	NA
magnesium	5.59E–04	NA	NA
manganese	4.14E–06	NA	NA
mercury	2.94E–08	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E–02	NA
uranium–total	1.47E–08	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		6.42E–08

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Table H.V.1-9
Summary of Risk Quantitation (radionuclides)
Target Receptor: Undeveloped Park User
Via Incidental Ingestion while Wading

Intake Equation = CS X EF X ED X IRsw

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
Cs	Concentration of radionuclides in surface water	csv	csv	csv	csv	

Ra_{226+8d}	3.5E-01	pCi/l		pCi/l
Rn_{222}		pCi/l		pCi/l
Sr_{90+1d}	2.1E+00	pCi/l		pCi/l
Tc_{99}		pCi/l		pCi/l
Th_{230}	3.1E-03	pCi/l		pCi/l
$Th_{232+10d}$	1.7E-04	pCi/l		pCi/l
$U_{235/236}$	7.5E-03	pCi/l		pCi/l
U_{238+2d}	9.0E-01	pCi/l		pCi/l
		pCi/l		pCi/l
		pCi/l		pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	7.7E+00	7.8E-10	6.0E-09
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	4.5E+01	3.6E-11	1.6E-09
Tc_{99}	NA	1.3E-12	NA
Th_{230}	6.7E-02	1.3E-11	8.7E-13
$Th_{232+10d}$	3.6E-03	1.7E-10	6.2E-13
$U_{235/236}$	1.6E-01	1.6E-11	2.6E-12
U_{238+2d}	2.0E+01	2.0E-11	3.9E-10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		8.0E-09

Table H.V.1-10
Summary of Risk Quantitation (radionuclides)
Target Receptor: Undeveloped Park User
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]+[CR \times EF \times ED \times ET_i \times (1-SH_i)]$

		child	youth	adult	senoir adult	
EF	Fraction of year spent exposured	0.11	0.28	0.11	0.07	(unitless)
ED	Exposure duration	6	12	38	14	years
ET_o	Fraction of day spent outdoors	0.04	0.08	0.08	0.04	(unitless)
ET_i	Fraction of day spent indoors	NA	NA	NA	NA	NA
SH_i	Shield factor indoors	0.5	0.5	0.5	0.5	(unitless)
SH_o	Shield factor outdoors					(unitless)
CR	Radionuclide specific concentrations	csv	csv	csv	csv	

Ra_{226+8d}	1.6E+00	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	3.7E-01	pCi/g	NA	pCi/g
Tc_{99}	2.5E-01	pCi/g	NA	pCi/g
Th_{230}	2.1E+00	pCi/g	NA	pCi/g
$Th_{232+10d}$	1.1E+00	pCi/g	NA	pCi/g
$U_{235/236}$	7.1E-02	pCi/g	NA	pCi/g
U_{238+2d}	3.9E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.1E+00	6.0E-06	6.4E-06
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	2.5E-01	NA	NA
Tc_{99}	1.7E-01	6.0E-13	1.0E-13
Th_{230}	1.4E+00	5.4E-11	7.7E-11
$Th_{232+10d}$	7.4E-01	8.5E-06	6.3E-06
$U_{235/236}$	4.7E-02	2.4E-07	1.1E-08
U_{238+2d}	2.6E+00	5.1E-08	1.3E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		1.3E-05

Table H.V.1-11
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.2E-09	mg/m^3			mg/m^3
arodor-1254	1.2E-11	mg/m^3			mg/m^3
arodor-1260		mg/m^3			mg/m^3
arsenic	2.2E-09	mg/m^3			mg/m^3
beryllium	2.5E-10	mg/m^3			mg/m^3
benzo(a)pyrene	9.3E-12	mg/m^3			mg/m^3
cadmium	2.4E-10	mg/m^3			mg/m^3
1,2-dichloroethane		mg/m^3			mg/m^3
magnesium	1.3E-06	mg/m^3			mg/m^3
manganese	3.4E-07	mg/m^3			mg/m^3
mercury	7.7E-11	mg/m^3			mg/m^3
silver	6.0E-10	mg/m^3			mg/m^3
2,3,7,8-tcdd		mg/m^3			mg/m^3
trichloroethene	6.4E-13	mg/m^3			mg/m^3
uranium-total	6.3E-09	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.V.1-11 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.2E-10	NA	NA
aroclor-1254	3.2E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.1E-10	NA	NA
beryllium	6.9E-11	NA	NA
benzo(a)pyrene	2.6E-12	NA	NA
cadmium	6.7E-11	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	3.5E-07	NA	NA
manganese	9.3E-08	1.4E-05	6.5E-03
mercury	2.1E-11	8.6E-05	2.5E-07
silver	1.6E-10	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.8E-13	NA	NA
uranium-total	1.7E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
Hazard Quotient Sum =			6.5E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	3.2E-10	NA	NA
aroclor-1254	3.2E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.1E-10	1.5E+01	9.2E-09
beryllium	6.9E-11	8.4E+00	5.8E-10
benzo(a)pyrene	2.6E-12	6.1E+00	1.6E-11
cadmium	6.7E-11	6.3E+00	4.2E-10
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	3.5E-07	NA	NA
manganese	9.3E-08	NA	NA
mercury	2.1E-11	NA	NA
silver	1.6E-10	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.8E-13	6.0E-03	1.1E-15
uranium-total	1.7E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			1.0E-08

Table H.V.1–12
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	20	m^3/day
EF	Exposure frequency	350	days/year
EDn	Exposure duration	70	Year
Ca	Concentration of radionuclides in air		(see table below)

Ra_{226+8d}	5.6E–07	pCi/m^3	pCi/m^3
Rn_{222}	7.5E+00	pCi/m^3	pCi/m^3
Sr_{90+1d}	1.4E–07	pCi/m^3	pCi/m^3
Tc_{99}	3.3E–07	pCi/m^3	pCi/m^3
Th_{230}	9.4E–07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	4.6E–07	pCi/m^3	pCi/m^3
$U_{235/236}$	4.6E–08	pCi/m^3	pCi/m^3
U_{238+2d}	2.1E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	2.7E–01	7.0E–09	1.9E–09
Rn_{222}	3.7E+06	7.3E–13	2.7E–06
Sr_{90+1d}	6.9E–02	6.2E–11	4.3E–12
Tc_{99}	1.6E–01	8.3E–12	1.4E–12
Th_{230}	4.6E–01	2.9E–08	1.3E–08
$Th_{232+10d}$	2.3E–01	1.1E–07	2.5E–08
$U_{235/236}$	2.2E–02	2.5E–08	5.6E–10
U_{238+2d}	1.0E+00	2.4E–08	2.5E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation	=	2.8E–06

Table H.V.1–13
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.3E+00	mg/kg			mg/kg
arodor–1254	2.2E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	3.8E+00	mg/kg			mg/kg
beryllium	4.5E–01	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	4.9E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.2E+03	mg/kg			mg/kg
manganese	6.5E+02	mg/kg			mg/kg
mercury	5.5E–02	mg/kg			mg/kg
silver	4.8E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	2.0E–03	mg/kg			mg/kg
uranium–total	7.2E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1-13 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.2E-06	4.0E-04	8.0E-03
aroclor-1254	5.4E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.3E-06	3.0E-04	3.1E-02
beryllium	1.1E-06	5.0E-03	2.2E-04
benzo(a)pyrene	4.9E-08	NA	NA
cadmium	1.2E-06	1.0E-03	1.2E-03
1,2-dichloroethane	NA	NA	NA
magnesium	5.4E-03	9.7E+00	5.6E-04
manganese	1.6E-03	1.4E-01	1.1E-02
mercury	1.4E-07	3.0E-04	4.5E-04
silver	1.2E-06	5.0E-03	2.4E-04
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-09	6.0E-03	8.2E-07
uranium-total	1.8E-05	3.0E-03	5.9E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.9E-02

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	3.2E-06	NA	NA
aroclor-1254	5.4E-08	7.7E+00	4.2E-07
aroclor-1260	NA	7.7E+00	
arsenic	9.3E-06	1.8E+00	1.6E-05
beryllium	1.1E-06	4.3E+00	4.8E-06
benzo(a)pyrene	4.9E-08	7.3E+00	3.6E-07
cadmium	1.2E-06	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	5.4E-03	NA	NA
manganese	1.6E-03	NA	NA
mercury	1.4E-07	NA	NA
silver	1.2E-06	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	4.9E-09	1.1E-02	5.4E-11
uranium-total	1.8E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		2.2E-05

000512

Table H.V.1-14
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	70 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	9.00E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	2.65E-04	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	1.77E-03	pCi/mg	pCi/mg
$Th_{232+10d}$	8.98E-04	pCi/mg	pCi/mg
$U_{235/236}$	1.12E-04	pCi/mg	pCi/mg
U_{238+2d}	2.40E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	3.97E+03	7.80E-10	3.10E-06
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	1.17E+03	3.60E-11	4.21E-08
Tc_{99}	1.10E+03	1.30E-12	1.43E-09
Th_{230}	7.81E+03	1.30E-11	1.01E-07
$Th_{232+10d}$	3.96E+03	1.70E-10	6.73E-07
$U_{235/236}$	4.94E+02	1.60E-11	7.90E-09
U_{238+2d}	1.06E+04	2.00E-11	2.12E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		4.13E-06

Table H.V.1–15
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E–02	1.30E+00	mg/kg		NA	mg/kg
arodor–1254	6.00E–02	2.20E–02	mg/kg		NA	mg/kg
arodor–1260	6.00E–02		mg/kg		NA	mg/kg
arsenic	1.00E–03	3.79E+00	mg/kg		NA	mg/kg
beryllium	1.00E–02	4.49E–01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E–01	2.00E–02	mg/kg		NA	mg/kg
cadmium	1.00E–02	4.90E–01	mg/kg		NA	mg/kg
1,2–dichloroethane	3.00E–01		mg/kg		NA	mg/kg
magnesium	1.00E–02	2.19E+03	mg/kg		NA	mg/kg
manganese	1.00E–02	6.47E+02	mg/kg		NA	mg/kg
mercury	5.00E–02	5.50E–02	mg/kg		NA	mg/kg
silver	1.00E–02	4.80E–01	mg/kg		NA	mg/kg
2,3,7,8–tcdd	3.00E–02		mg/kg		NA	mg/kg
trichloroethene	3.00E–01	2.00E–03	mg/kg		NA	mg/kg
uranium–total	1.00E–02	7.20E+00	mg/kg		NA	mg/kg
	NA		mg/kg			

References

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Table H.V.1-15 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.02E-06	6.00E-05	1.71E-02
aroclor-1254	1.04E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.99E-07	2.85E-04	1.05E-03
beryllium	3.54E-07	5.00E-03	7.07E-05
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	3.86E-07	5.00E-05	7.72E-03
1,2-dichloroethane	NA	NA	NA
magnesium	1.73E-03	4.85E-01	3.56E-03
manganese	5.10E-04	4.20E-03	1.21E-01
mercury	2.17E-07	4.50E-05	4.81E-03
silver	3.78E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.73E-08	5.88E-03	8.04E-06
uranium-total	5.67E-06	1.50E-04	3.78E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			1.93E-01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.02E-06	NA	NA
aroclor-1254	1.04E-07	1.03E+01	1.07E-06
aroclor-1260	NA	1.03E+01	
arsenic	2.99E-07	1.84E+00	5.50E-07
beryllium	3.54E-07	4.30E+00	1.52E-06
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	3.86E-07	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	1.73E-03	NA	NA
manganese	5.10E-04	NA	NA
mercury	2.17E-07	NA	NA
silver	3.78E-07	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	4.73E-08	1.12E-02	5.30E-10
uranium-total	5.67E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			3.14E-06

0005335

Table H.V.1–16
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor–1254		mg/l			mg/l
arodor–1260		mg/l			mg/l
arsenic	2.69E–04	mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2–dichloroethane		mg/l			mg/l
magnesium	1.05E+00	mg/l			mg/l
manganese	6.38E–03	mg/l			mg/l
mercury	1.99E–06	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8–tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium–total	5.61E–03	mg/l			mg/l
		mg/l			

References

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Table H.V.1–16 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	4.00E–04	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	7.36E–06	3.00E–04	2.45E–02
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E–03	NA
1,2–dichloroethane	NA	NA	NA
magnesium	2.88E–02	9.70E+00	2.97E–03
manganese	1.75E–04	5.00E–03	3.49E–02
mercury	5.46E–08	3.00E–04	1.82E–04
silver	NA	5.00E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	6.00E–03	NA
uranium–total	1.54E–04	3.00E–03	5.12E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.14E–01

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	7.70E+00	NA
aroclor–1260	NA	7.70E+00	NA
arsenic	7.36E–06	1.75E+00	1.29E–05
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	9.10E–02	NA
magnesium	2.88E–02	NA	NA
manganese	1.75E–04	NA	NA
mercury	5.46E–08	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E–02	NA
uranium–total	1.54E–04	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.29E–05

Table H.V.1–17
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)		2 l/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		70 Year
FI	Fractional intake for radionuclides		1 (Unitless)
Cw	Concentration of radionuclides in groundwater		(see table below)

Ra_{226+8d}		pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	6.5E−01	pCi/l	pCi/l
Tc_{99}	2.2E+01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	1.8E−01	pCi/l	pCi/l
U_{238+2d}	2.2E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	NA	7.8E−10	NA
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	3.2E+04	3.6E−11	1.1E−06
Tc_{99}	1.1E+06	1.3E−12	1.4E−06
Th_{230}	NA	1.3E−11	NA
$Th_{232+10d}$	NA	1.7E−10	NA
$U_{235/236}$	8.7E+03	1.6E−11	1.4E−07
U_{238+2d}	1.1E+05	2.0E−11	2.1E−06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 4.8E−06

Table H.V.1-18
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2-day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	25550	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1254	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1260	NA	mg/cm^2-day		NA	mg/cm^2-day
arsenic	6.72E-10	mg/cm^2-day		NA	mg/cm^2-day
beryllium	NA	mg/cm^2-day		NA	mg/cm^2-day
benzo(a)pyrene	NA	mg/cm^2-day		NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day		NA	mg/cm^2-day
1,2-dichloroethane	NA	mg/cm^2-day		NA	mg/cm^2-day
magnesium	2.63E-06	mg/cm^2-day		NA	mg/cm^2-day
manganese	1.59E-08	mg/cm^2-day		NA	mg/cm^2-day
mercury	4.98E-12	mg/cm^2-day		NA	mg/cm^2-day
silver	NA	mg/cm^2-day		NA	mg/cm^2-day
2,3,7,8-tcdd	NA	mg/cm^2-day		NA	mg/cm^2-day
trichloroethene	NA	mg/cm^2-day		NA	mg/cm^2-day
uranium-total	1.40E-08	mg/cm^2-day		NA	mg/cm^2-day
	NA	mg/cm^2-day			

References

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Table H.V.1–18 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	6.00E–05	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.12E–07	2.85E–04	7.42E–04
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E–05	NA
1,2–dichloroethane	NA	NA	NA
magnesium	8.29E–04	4.85E–01	1.71E–03
manganese	5.02E–06	4.20E–03	1.20E–03
mercury	1.57E–09	4.50E–05	3.49E–05
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	5.88E–03	NA
uranium–total	4.42E–06	1.50E–04	2.94E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.31E–02

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
arsenic	2.12E–07	1.84E+00	3.90E–07
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	1.01E–01	NA
magnesium	8.29E–04	NA	NA
manganese	5.02E–06	NA	NA
mercury	1.57E–09	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E–02	NA
uranium–total	4.42E–06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		3.90E–07

025000

Table II.V.1-19
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units
antimony	1.4E-05	mg/kg
arodor-1254	6.7E-07	mg/kg
arodor-1260		mg/kg
arsenic	1.9E-05	mg/kg
beryllium	4.5E-07	mg/kg
benzo(a)pyrene	6.8E-07	mg/kg
cadmium	7.5E-06	mg/kg
1,2-dichloroethane		mg/kg
magnesium	5.5E-01	mg/kg
manganese	3.4E-03	mg/kg
mercury	6.3E-04	mg/kg
silver	3.0E-05	mg/kg
2,3,7,8-tcdd		mg/kg
trichloroethene	1.0E-09	mg/kg
uranium-total	1.4E-06	mg/kg
		mg/kg

Compound	Concentration	Units
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg

References

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Table H.V.1-19 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.4E-08	4.0E-04	3.5E-05
aroclor-1254	6.9E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.9E-08	3.0E-04	6.5E-05
beryllium	4.6E-10	5.0E-03	9.2E-08
benzo(a)pyrene	7.0E-10	NA	NA
cadmium	7.8E-09	1.0E-03	7.8E-06
1,2-dichloroethane	NA	NA	NA
magnesium	5.7E-04	9.7E+00	5.9E-05
manganese	3.5E-06	1.4E-01	2.5E-05
mercury	6.4E-07	3.0E-04	2.1E-03
silver	3.0E-08	5.0E-03	6.1E-06
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.0E-12	6.0E-03	1.7E-10
uranium-total	1.4E-09	3.0E-03	4.8E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.3E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.4E-08	NA	NA
aroclor-1254	6.9E-10	7.7E+00	5.3E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	1.9E-08	1.8E+00	3.4E-08
beryllium	4.6E-10	4.3E+00	2.0E-09
benzo(a)pyrene	7.0E-10	7.3E+00	5.1E-09
cadmium	7.8E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	5.7E-04	NA	NA
manganese	3.5E-06	NA	NA
mercury	6.4E-07	NA	NA
silver	3.0E-08	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.0E-12	1.1E-02	1.1E-14
uranium-total	1.4E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.7E-08

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Table H.V.1–20
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	2.8E–04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	1.0E–02	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	5.8E–06	pCi/kg	pCi/kg
$Th_{232+10d}$	2.9E–06	pCi/kg	pCi/kg
$U_{235/236}$	2.2E–05	pCi/kg	pCi/kg
U_{238+2d}	4.7E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	5.2E–01	7.8E–10	4.0E–10
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.8E+01	3.6E–11	6.6E–10
Tc_{99}	1.9E+03	1.3E–12	2.4E–09
Th_{230}	1.1E–02	1.3E–11	1.4E–13
$Th_{232+10d}$	5.4E–03	1.7E–10	9.1E–13
$U_{235/236}$	4.1E–02	1.6E–11	6.6E–13
U_{238+2d}	8.6E–01	2.0E–11	1.7E–11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		3.5E–09

Table H.V.1–21
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.4E–03	mg/kg			mg/kg
arodor–1254	2.1E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	5.7E–04	mg/kg			mg/kg
beryllium	4.0E–07	mg/kg			mg/kg
benzo(a)pyrene	2.2E–04	mg/kg			mg/kg
cadmium	1.4E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	4.4E+02	mg/kg			mg/kg
manganese	2.9E+00	mg/kg			mg/kg
mercury	1.1E–03	mg/kg			mg/kg
silver	2.0E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.2E–07	mg/kg			mg/kg
uranium–total	4.2E–03	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1–21 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	5.6E–06	4.0E–04	1.4E–02
aroclor–1254	8.7E–07	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.3E–06	3.0E–04	7.8E–03
beryllium	1.7E–09	5.0E–03	3.3E–07
benzo(a)pyrene	8.8E–07	NA	NA
cadmium	5.6E–05	1.0E–03	5.6E–02
1,2–dichloroethane	NA	NA	NA
magnesium	1.8E+00	9.7E+00	1.9E–01
manganese	1.2E–02	1.4E–01	8.6E–02
mercury	4.6E–06	3.0E–04	1.5E–02
silver	8.1E–04	5.0E–03	1.6E–01
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.3E–09	6.0E–03	2.2E–07
uranium–total	1.7E–05	3.0E–03	5.8E–03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.4E–01

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	5.6E–06	NA	NA
aroclor–1254	8.7E–07	7.7E+00	6.7E–06
aroclor–1260	NA	7.7E+00	NA
arsenic	2.3E–06	1.8E+00	4.1E–06
beryllium	1.7E–09	4.3E+00	7.1E–09
benzo(a)pyrene	8.8E–07	7.3E+00	6.5E–06
cadmium	5.6E–05	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	1.8E+00	NA	NA
manganese	1.2E–02	NA	NA
mercury	4.6E–06	NA	NA
silver	8.1E–04	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.3E–09	1.1E–02	1.4E–11
uranium–total	1.7E–05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.7E–05

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Table H.V.1–22
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	5.1E−01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	5.0E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	4.8E−03	pCi/kg	pCi/kg
$Th_{232+10d}$	2.4E−03	pCi/kg	pCi/kg
$U_{235/236}$	6.9E−02	pCi/kg	pCi/kg
U_{238+2d}	1.4E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	3.7E+03	7.8E−10	2.9E−06
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	3.7E+05	3.6E−11	1.3E−05
Tc_{99}	8.8E+06	1.3E−12	1.1E−05
Th_{230}	3.5E+01	1.3E−11	4.6E−10
$Th_{232+10d}$	1.8E+01	1.7E−10	3.0E−09
$U_{235/236}$	5.0E+02	1.6E−11	8.1E−09
U_{238+2d}	1.0E+04	2.0E−11	2.1E−07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 2.8E−05

Table H.V.1–23
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.6E–01	mg/kg			mg/kg
arodor–1254	2.8E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	1.5E–01	mg/kg			mg/kg
beryllium	4.5E–03	mg/kg			mg/kg
benzo(a)pyrene	2.3E–04	mg/kg			mg/kg
cadmium	2.7E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.2E+03	mg/kg			mg/kg
manganese	1.6E+02	mg/kg			mg/kg
mercury	5.0E–02	mg/kg			mg/kg
silver	1.9E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.2E–03	mg/kg			mg/kg
uranium–total	8.9E–02	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1-23 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.2E-04	4.0E-04	5.4E-01
aroclor-1254	2.3E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.3E-04	3.0E-04	4.3E-01
beryllium	3.8E-06	5.0E-03	7.5E-04
benzo(a)pyrene	1.9E-07	NA	NA
cadmium	2.3E-04	1.0E-03	2.3E-01
1,2-dichloroethane	NA	NA	NA
magnesium	1.8E+00	9.7E+00	1.9E-01
manganese	1.4E-01	1.4E-01	9.7E-01
mercury	4.1E-05	3.0E-04	1.4E-01
silver	1.6E-04	5.0E-03	3.2E-02
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.7E-06	6.0E-03	4.4E-04
uranium-total	7.4E-05	3.0E-03	2.5E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.5E+00

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	2.2E-04	NA	NA
aroclor-1254	2.3E-07	7.7E+00	1.8E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	1.3E-04	1.8E+00	2.2E-04
beryllium	3.8E-06	4.3E+00	1.6E-05
benzo(a)pyrene	1.9E-07	7.3E+00	1.4E-06
cadmium	2.3E-04	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.8E+00	NA	NA
manganese	1.4E-01	NA	NA
mercury	4.1E-05	NA	NA
silver	1.6E-04	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.7E-06	1.1E-02	2.9E-08
uranium-total	7.4E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		2.4E-04

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Table H.V.1–24
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	1.4E+01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	6.7E+02	pCi/kg	pCi/kg
Tc_{99}	2.5E+03	pCi/kg	pCi/kg
Th_{230}	1.5E+00	pCi/kg	pCi/kg
$Th_{232+10d}$	7.6E–01	pCi/kg	pCi/kg
$U_{235/236}$	1.8E+00	pCi/kg	pCi/kg
U_{238+2d}	3.1E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	2.0E+04	7.8E–10	1.6E–05
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.0E+06	3.6E–11	3.6E–05
Tc_{99}	3.8E+06	1.3E–12	4.9E–06
Th_{230}	2.3E+03	1.3E–11	2.9E–08
$Th_{232+10d}$	1.1E+03	1.7E–10	1.9E–07
$U_{235/236}$	2.7E+03	1.6E–11	4.3E–08
U_{238+2d}	4.6E+04	2.0E–11	9.3E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 5.8E–05

Table H.V.1–25
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	70 Year
ET_i	Fraction of day spent indoors	0.76 (unitless)
ET_o	Fraction of day spent outdoors	0.24 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	9.00E−01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	2.65E−01	pCi/g	NA	pCi/g
Tc_{99}	2.50E−01	pCi/g	NA	pCi/g
Th_{230}	1.77E+00	pCi/g	NA	pCi/g
$Th_{232+10d}$	8.98E−01	pCi/g	NA	pCi/g
$U_{235/236}$	1.12E−01	pCi/g	NA	pCi/g
U_{238+2d}	2.40E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	TLCR (unitless)
Ra_{226+8d}	3.7E+01	6.0E−06	2.2E−04
Rn_{222}	NA	1.2E−09	NA
Sr_{90+1d}	1.1E+01	NA	
Tc_{99}	1.0E+01	6.0E−13	6.2E−12
Th_{230}	7.4E+01	5.4E−11	4.0E−09
$Th_{232+10d}$	3.7E+01	8.5E−06	3.2E−04
$U_{235/236}$	4.7E+00	2.4E−07	1.1E−06
U_{238+2d}	1.0E+02	5.1E−08	5.1E−06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		5.5E−04

Table H.V.1–26
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
antimony	1.2E–09	mg/m^3
arodor–1254	1.2E–11	mg/m^3
arodor–1260		mg/m^3
arsenic	2.2E–09	mg/m^3
beryllium	2.5E–10	mg/m^3
benzo(a)pyrene	9.3E–12	mg/m^3
cadmium	2.4E–10	mg/m^3
1,2–dichloroethane		mg/m^3
magnesium	1.3E–06	mg/m^3
manganese	3.4E–07	mg/m^3
mercury	7.7E–11	mg/m^3
silver	6.0E–10	mg/m^3
2,3,7,8–tcdd		mg/m^3
trichloroethene	6.4E–13	mg/m^3
uranium–total	6.3E–09	mg/m^3
		mg/m^3

Compound	Concentration	Units
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3

References

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Table H.V.1-26 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	9.0E-10	NA	NA
aroclor-1254	9.1E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.7E-09	NA	NA
beryllium	1.9E-10	NA	NA
benzo(a)pyrene	7.2E-12	NA	NA
cadmium	1.9E-10	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	9.9E-07	NA	NA
manganese	2.6E-07	1.4E-05	1.8E-02
mercury	5.9E-11	8.6E-05	6.9E-07
silver	4.6E-10	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-13	NA	NA
uranium-total	4.8E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
Hazard Quotient Sum =			1.8E-02

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	7.7E-11	NA	NA
aroclor-1254	7.8E-13	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.5E-10	1.5E+01	2.2E-09
beryllium	1.7E-11	8.4E+00	1.4E-10
benzo(a)pyrene	6.1E-13	6.1E+00	3.7E-12
cadmium	1.6E-11	6.3E+00	1.0E-10
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	8.5E-08	NA	NA
manganese	2.2E-08	NA	NA
mercury	5.0E-12	NA	NA
silver	3.9E-11	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.2E-14	6.0E-03	2.5E-16
uranium-total	4.1E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			2.4E-09

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Table H.V.1–27
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		12 m^3/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		6 Year
Ca	Concentration of radionuclides in air		(see table below)
Ra_{226+8d}	5.6E–07	pCi/m^3	pCi/m^3
Rn_{222}	7.5E+00	pCi/m^3	pCi/m^3
Sr_{90+1d}	1.4E–07	pCi/m^3	pCi/m^3
Tc_{99}	3.3E–07	pCi/m^3	pCi/m^3
Th_{230}	9.4E–07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	4.6E–07	pCi/m^3	pCi/m^3
$U_{235/236}$	4.6E–08	pCi/m^3	pCi/m^3
U_{238+2d}	2.1E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.4E–02	7.0E–09	9.8E–11
Rn_{222}	1.9E+05	7.3E–13	1.4E–07
Sr_{90+1d}	3.5E–03	6.2E–11	2.2E–13
Tc_{99}	8.4E–03	8.3E–12	7.0E–14
Th_{230}	2.4E–02	2.9E–08	6.9E–10
$Th_{232+10d}$	1.2E–02	1.1E–07	1.3E–09
$U_{235/236}$	1.1E–03	2.5E–08	2.9E–11
U_{238+2d}	5.3E–02	2.4E–08	1.3E–09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		1.4E–07

Table H.V.1–28
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	200	mg/day
CF	Conversion factor	1.0E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for nOff–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190	days
CS	Concentration of chemicals in soil	(see table below)	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.3E+00	mg/kg			mg/kg
arodor–1254	2.2E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	3.8E+00	mg/kg			mg/kg
beryllium	4.5E–01	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	4.9E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.2E+03	mg/kg			mg/kg
manganese	6.5E+02	mg/kg			mg/kg
mercury	5.5E–02	mg/kg			mg/kg
silver	4.8E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	2.0E–03	mg/kg			mg/kg
uranium–total	7.2E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1-28 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.7E-05	4.0E-04	4.2E-02
aroclor-1254	2.8E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	4.8E-05	3.0E-04	1.6E-01
beryllium	5.7E-06	5.0E-03	1.1E-03
benzo(a)pyrene	2.6E-07	NA	NA
cadmium	6.3E-06	1.0E-03	6.3E-03
1,2-dichloroethane	NA	NA	NA
magnesium	2.8E-02	9.7E+00	2.9E-03
manganese	8.3E-03	1.4E-01	5.9E-02
mercury	7.0E-07	3.0E-04	2.3E-03
silver	6.1E-06	5.0E-03	1.2E-03
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.6E-08	6.0E-03	4.3E-06
uranium-total	9.2E-05	3.0E-03	3.1E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.1E-01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.4E-06	NA	NA
aroclor-1254	2.4E-08	7.7E+00	1.9E-07
aroclor-1260	NA	7.7E+00	
arsenic	4.2E-06	1.8E+00	7.3E-06
beryllium	4.9E-07	4.3E+00	2.1E-06
benzo(a)pyrene	2.2E-08	7.3E+00	1.6E-07
cadmium	5.4E-07	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	2.4E-03	NA	NA
manganese	7.1E-04	NA	NA
mercury	6.0E-08	NA	NA
silver	5.3E-07	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	2.2E-09	1.1E-02	2.4E-11
uranium-total	7.9E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		9.7E-06

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Table H.V.1-29
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	6 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	9.00E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	2.65E-04	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	1.77E-03	pCi/mg	pCi/mg
$Th_{232+10d}$	8.98E-04	pCi/mg	pCi/mg
$U_{235/236}$	1.12E-04	pCi/mg	pCi/mg
U_{238+2d}	2.40E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	3.78E+02	7.80E-10	2.95E-07
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	1.11E+02	3.60E-11	4.01E-09
Tc_{99}	1.05E+02	1.30E-12	1.37E-10
Th_{230}	7.43E+02	1.30E-11	9.66E-09
$Th_{232+10d}$	3.77E+02	1.70E-10	6.41E-08
$U_{235/236}$	4.70E+01	1.60E-11	7.53E-10
U_{238+2d}	1.01E+03	2.00E-11	2.02E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		3.94E-07

Table H.V.1–30
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	2000 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E–02	1.30E+00	mg/kg		NA	mg/kg
arodor–1254	6.00E–02	2.20E–02	mg/kg		NA	mg/kg
arodor–1260	6.00E–02		mg/kg		NA	mg/kg
arsenic	1.00E–03	3.79E+00	mg/kg		NA	mg/kg
beryllium	1.00E–02	4.49E–01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E–01	2.00E–02	mg/kg		NA	mg/kg
cadmium	1.00E–02	4.90E–01	mg/kg		NA	mg/kg
1,2–dichloroethane	3.00E–01		mg/kg		NA	mg/kg
magnesium	1.00E–02	2.19E+03	mg/kg		NA	mg/kg
manganese	1.00E–02	6.47E+02	mg/kg		NA	mg/kg
mercury	5.00E–02	5.50E–02	mg/kg		NA	mg/kg
silver	1.00E–02	4.80E–01	mg/kg		NA	mg/kg
2,3,7,8–tcdd	3.00E–02		mg/kg		NA	mg/kg
trichloroethene	3.00E–01	2.00E–03	mg/kg		NA	mg/kg
uranium–total	1.00E–02	7.20E+00	mg/kg		NA	mg/kg
	NA		mg/kg			

References

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Table H.V.1-30 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Dermal Contact with Soil

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.66E-06	6.00E-05	2.77E-02
aroclor-1254	1.69E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	4.85E-07	2.85E-04	1.70E-03
beryllium	5.74E-07	5.00E-03	1.15E-04
benzo(a)pyrene	7.67E-07	NA	NA
cadmium	6.26E-07	5.00E-05	1.25E-02
1,2-dichloroethane	NA	NA	NA
magnesium	2.80E-03	4.85E-01	5.77E-03
manganese	8.27E-04	4.20E-03	1.97E-01
mercury	3.52E-07	4.50E-05	7.81E-03
silver	6.14E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.67E-08	5.88E-03	1.30E-05
uranium-total	9.21E-06	1.50E-04	6.14E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.14E-01

Compound	TLCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.42E-07	NA	NA
aroclor-1254	1.45E-08	1.03E+01	1.49E-07
aroclor-1260	NA	1.03E+01	
arsenic	4.15E-08	1.84E+00	7.65E-08
beryllium	4.92E-08	4.30E+00	2.12E-07
benzo(a)pyrene	6.58E-08	NA	NA
cadmium	5.37E-08	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	2.40E-04	NA	NA
manganese	7.09E-05	NA	NA
mercury	3.01E-08	NA	NA
silver	5.26E-08	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	6.58E-09	1.12E-02	7.38E-11
uranium-total	7.89E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.37E-07

000518

Table H.V.1-31
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	2.69E-04	mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	1.05E+00	mg/l			mg/l
manganese	6.38E-03	mg/l			mg/l
mercury	1.99E-06	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	5.61E-03	mg/l			mg/l
		mg/l			

References

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Table H.V.1-31 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.00E-04	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.72E-05	3.00E-04	5.72E-02
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	6.73E-02	9.70E+00	6.93E-03
manganese	4.08E-04	5.00E-03	8.15E-02
mercury	1.27E-07	3.00E-04	4.24E-04
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	3.58E-04	3.00E-03	1.19E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.66E-01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	1.47E-06	1.75E+00	2.58E-06
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	5.76E-03	NA	NA
manganese	3.49E-05	NA	NA
mercury	1.09E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	3.07E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		2.58E-06

000560

Table H.V.1–32
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}		pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	6.5E–01	pCi/l	pCi/l
Tc_{99}	2.2E+01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	1.8E–01	pCi/l	pCi/l
U_{238+2d}	2.2E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	NA	7.8E–10	NA
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.4E+03	3.6E–11	4.9E–08
Tc_{99}	4.7E+04	1.3E–12	6.1E–08
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	3.7E+02	1.6E–11	5.9E–09
U_{238+2d}	4.6E+03	2.0E–11	9.1E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 2.1E–07

Table H.V.1-33
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2-day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1254	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1260	NA	mg/cm^2-day		NA	mg/cm^2-day
arsenic	6.72E-10	mg/cm^2-day		NA	mg/cm^2-day
beryllium	NA	mg/cm^2-day		NA	mg/cm^2-day
benzo(a)pyrene	NA	mg/cm^2-day		NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day		NA	mg/cm^2-day
1,2-dichloroethane	NA	mg/cm^2-day		NA	mg/cm^2-day
magnesium	2.63E-06	mg/cm^2-day		NA	mg/cm^2-day
manganese	1.59E-08	mg/cm^2-day		NA	mg/cm^2-day
mercury	4.98E-12	mg/cm^2-day		NA	mg/cm^2-day
silver	NA	mg/cm^2-day		NA	mg/cm^2-day
2,3,7,8-tcdd	NA	mg/cm^2-day		NA	mg/cm^2-day
trichloroethene	NA	mg/cm^2-day		NA	mg/cm^2-day
uranium-total	1.40E-08	mg/cm^2-day		NA	mg/cm^2-day
	NA	mg/cm^2-day			

References

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Table H.V.1-33 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	6.00E-05	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.87E-07	2.85E-04	3.46E-03
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	3.87E-03	4.85E-01	7.97E-03
manganese	2.34E-05	4.20E-03	5.58E-03
mercury	7.32E-09	4.50E-05	1.63E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	2.06E-05	1.50E-04	1.37E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.55E-01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	8.46E-08	1.84E+00	1.56E-07
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	3.31E-04	NA	NA
manganese	2.01E-06	NA	NA
mercury	6.28E-10	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	1.77E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.56E-07

0002563

Table H.V.1–34
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.4E–05	mg/kg			mg/kg
arodor–1254	6.7E–07	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	1.9E–05	mg/kg			mg/kg
beryllium	4.5E–07	mg/kg			mg/kg
benzo(a)pyrene	6.8E–07	mg/kg			mg/kg
cadmium	7.5E–06	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	5.5E–01	mg/kg			mg/kg
manganese	3.4E–03	mg/kg			mg/kg
mercury	6.3E–04	mg/kg			mg/kg
silver	3.0E–05	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	1.0E–09	mg/kg			mg/kg
uranium–total	1.4E–06	mg/kg			mg/kg
		mg/kg			

References

000564

Table H.V.1-34 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.6E-08	4.0E-04	6.4E-05
aroclor-1254	1.3E-09	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.5E-08	3.0E-04	1.2E-04
beryllium	8.4E-10	5.0E-03	1.7E-07
benzo(a)pyrene	1.3E-09	NA	NA
cadmium	1.4E-08	1.0E-03	1.4E-05
1,2-dichloroethane	NA	NA	NA
magnesium	1.0E-03	9.7E+00	1.1E-04
manganese	6.3E-06	1.4E-01	4.5E-05
mercury	1.2E-06	3.0E-04	3.9E-03
silver	5.5E-08	5.0E-03	1.1E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.9E-12	6.0E-03	3.1E-10
uranium-total	2.6E-09	3.0E-03	8.7E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			4.3E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	2.2E-09	NA	NA
aroclor-1254	1.1E-10	7.7E+00	8.3E-10
aroclor-1260	NA	7.7E+00	NA
arsenic	3.0E-09	1.8E+00	5.3E-09
beryllium	7.2E-11	4.3E+00	3.1E-10
benzo(a)pyrene	1.1E-10	7.3E+00	7.9E-10
cadmium	1.2E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	8.9E-05	NA	NA
manganese	5.4E-07	NA	NA
mercury	1.0E-07	NA	NA
silver	4.7E-09	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.6E-13	1.1E-02	1.8E-15
uranium-total	2.2E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			7.3E-09

0005951

Table H.V.1–35
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	2.8E–04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	1.0E–02	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	5.8E–06	pCi/kg	pCi/kg
$Th_{232+10d}$	2.9E–06	pCi/kg	pCi/kg
$U_{235/236}$	2.2E–05	pCi/kg	pCi/kg
U_{238+2d}	4.7E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.7E–02	7.8E–10	1.3E–11
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	6.1E–01	3.6E–11	2.2E–11
Tc_{99}	6.3E+01	1.3E–12	8.1E–11
Th_{230}	3.5E–04	1.3E–11	4.6E–15
$Th_{232+10d}$	1.8E–04	1.7E–10	3.1E–14
$U_{235/236}$	1.4E–03	1.6E–11	2.2E–14
U_{238+2d}	2.9E–02	2.0E–11	5.7E–13
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 1.2E–10

Table H.V.1-36
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.4E-03	mg/kg			mg/kg
arodor-1254	2.1E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	5.7E-04	mg/kg			mg/kg
beryllium	4.0E-07	mg/kg			mg/kg
benzo(a)pyrene	2.2E-04	mg/kg			mg/kg
cadmium	1.4E-02	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.4E+02	mg/kg			mg/kg
manganese	2.9E+00	mg/kg			mg/kg
mercury	1.1E-03	mg/kg			mg/kg
silver	2.0E-01	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.2E-07	mg/kg			mg/kg
uranium-total	4.2E-03	mg/kg			mg/kg
		mg/kg			

References

Table H.V.1-36 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.9E-05	4.0E-04	1.5E-01
aroclor-1254	9.1E-06	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.5E-05	3.0E-04	8.2E-02
beryllium	1.7E-08	5.0E-03	3.5E-06
benzo(a)pyrene	9.3E-06	NA	NA
cadmium	5.9E-04	1.0E-03	5.9E-01
1,2-dichloroethane	NA	NA	NA
magnesium	1.9E+01	9.7E+00	2.0E+00
manganese	1.3E-01	1.4E-01	9.1E-01
mercury	4.9E-05	3.0E-04	1.6E-01
silver	8.5E-03	5.0E-03	1.7E+00
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.4E-08	6.0E-03	2.3E-06
uranium-total	1.8E-04	3.0E-03	6.0E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.6E+00

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	5.0E-06	NA	NA
aroclor-1254	7.8E-07	7.7E+00	6.0E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	2.1E-06	1.8E+00	3.7E-06
beryllium	1.5E-09	4.3E+00	6.4E-09
benzo(a)pyrene	8.0E-07	7.3E+00	5.8E-06
cadmium	5.1E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.6E+00	NA	NA
manganese	1.1E-02	NA	NA
mercury	4.2E-06	NA	NA
silver	7.3E-04	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.2E-09	1.1E-02	1.3E-11
uranium-total	1.6E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.6E-05

000598

Table H.V.1-37
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	5.1E-01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	5.0E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	4.8E-03	pCi/kg	pCi/kg
$Th_{232+10d}$	2.4E-03	pCi/kg	pCi/kg
$U_{235/236}$	6.9E-02	pCi/kg	pCi/kg
U_{238+2d}	1.4E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	7.2E+02	7.8E-10	5.6E-07
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	7.1E+04	3.6E-11	2.5E-06
Tc_{99}	1.7E+06	1.3E-12	2.2E-06
Th_{230}	6.8E+00	1.3E-11	8.8E-11
$Th_{232+10d}$	3.5E+00	1.7E-10	5.9E-10
$U_{235/236}$	9.7E+01	1.6E-11	1.6E-09
U_{238+2d}	2.0E+03	2.0E-11	4.0E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 5.4E-06

Table H.V.1-38
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times FF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.6E-01	mg/kg			mg/kg
arodor-1254	2.8E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	1.5E-01	mg/kg			mg/kg
beryllium	4.5E-03	mg/kg			mg/kg
benzo(a)pyrene	2.3E-04	mg/kg			mg/kg
cadmium	2.7E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	2.2E+03	mg/kg			mg/kg
manganese	1.6E+02	mg/kg			mg/kg
mercury	5.0E-02	mg/kg			mg/kg
silver	1.9E-01	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.2E-03	mg/kg			mg/kg
uranium-total	8.9E-02	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1–38 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	8.8E–04	4.0E–04	2.2E+00
aroclor–1254	9.5E–07	NA	NA
aroclor–1260	NA	NA	NA
arsenic	5.2E–04	3.0E–04	1.7E+00
beryllium	1.5E–05	5.0E–03	3.0E–03
benzo(a)pyrene	7.8E–07	NA	NA
cadmium	9.1E–04	1.0E–03	9.1E–01
1,2–dichloroethane	NA	NA	NA
magnesium	7.4E+00	9.7E+00	7.7E–01
manganese	5.5E–01	1.4E–01	3.9E+00
mercury	1.7E–04	3.0E–04	5.6E–01
silver	6.5E–04	5.0E–03	1.3E–01
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.1E–05	6.0E–03	1.8E–03
uranium–total	3.0E–04	3.0E–03	1.0E–01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.0E+01

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	7.6E–05	NA	NA
aroclor–1254	8.1E–08	7.7E+00	6.2E–07
aroclor–1260	NA	7.7E+00	NA
arsenic	4.4E–05	1.8E+00	7.8E–05
beryllium	1.3E–06	4.3E+00	5.6E–06
benzo(a)pyrene	6.7E–08	7.3E+00	4.9E–07
cadmium	7.8E–05	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	6.4E–01	NA	NA
manganese	4.7E–02	NA	NA
mercury	1.4E–05	NA	NA
silver	5.6E–05	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	9.2E–07	1.1E–02	1.0E–08
uranium–total	2.6E–05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		8.4E–05

000574

Table H.V.1–39
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	1.4E+01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	6.7E+02	pCi/kg	pCi/kg
Tc_{99}	2.5E+03	pCi/kg	pCi/kg
Th_{230}	1.5E+00	pCi/kg	pCi/kg
$Th_{232+10d}$	7.6E–01	pCi/kg	pCi/kg
$U_{235/236}$	1.8E+00	pCi/kg	pCi/kg
U_{238+2d}	3.1E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.5E+03	7.8E–10	1.2E–06
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	7.4E+04	3.6E–11	2.7E–06
Tc_{99}	2.8E+05	1.3E–12	3.6E–07
Th_{230}	1.7E+02	1.3E–11	2.2E–09
$Th_{232+10d}$	8.5E+01	1.7E–10	1.4E–08
$U_{235/236}$	2.0E+02	1.6E–11	3.2E–09
U_{238+2d}	3.5E+03	2.0E–11	6.9E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 4.3E–06

Table H.V.1–40
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	6 Year
ET_i	Fraction of day spent indoors	0.92 (unitless)
ET_o	Fraction of day spent outdoors	0.08 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	9.00E−01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	2.65E−01	pCi/g	NA	pCi/g
Tc_{99}	2.50E−01	pCi/g	NA	pCi/g
Th_{230}	1.77E+00	pCi/g	NA	pCi/g
$Th_{232+10d}$	8.98E−01	pCi/g	NA	pCi/g
$U_{235/236}$	1.12E−01	pCi/g	NA	pCi/g
U_{238+2d}	2.40E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	TLCR (unitless)
Ra_{226+8d}	2.8E+00	6.0E−06	1.7E−05
Rn_{222}	NA	1.2E−09	NA
Sr_{90+1d}	8.2E−01	NA	
Tc_{99}	7.8E−01	6.0E−13	4.7E−13
Th_{230}	5.5E+00	5.4E−11	3.0E−10
$Th_{232+10d}$	2.8E+00	8.5E−06	2.4E−05
$U_{235/236}$	3.5E−01	2.4E−07	8.4E−08
U_{238+2d}	7.5E+00	5.1E−08	3.8E−07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 4.1E−05

Table H.V.1–41
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.8E–09	mg/m^3			mg/m^3
arodor–1254	5.3E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	3.9E–09	mg/m^3			mg/m^3
beryllium	4.6E–10	mg/m^3			mg/m^3
benzo(a)pyrene	1.3E–11	mg/m^3			mg/m^3
cadmium	3.9E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	5.7E–06	mg/m^3			mg/m^3
manganese	5.2E–07	mg/m^3			mg/m^3
mercury	1.7E–10	mg/m^3			mg/m^3
silver	1.3E–09	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	7.7E–13	mg/m^3			mg/m^3
uranium–total	1.2E–08	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.V.1–41 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	7.6E–10	NA	NA
aroclor–1254	1.4E–11	NA	NA
aroclor–1260	NA	NA	NA
arsenic	1.1E–09	NA	NA
beryllium	1.2E–10	NA	NA
benzo(a)pyrene	3.5E–12	NA	NA
cadmium	1.1E–10	NA	NA
1,2–dichloroethane	NA	2.9E–03	NA
magnesium	1.6E–06	NA	NA
manganese	1.4E–07	1.4E–05	1.0E–02
mercury	4.7E–11	8.6E–05	5.5E–07
silver	3.6E–10	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	2.1E–13	NA	NA
uranium–total	3.2E–09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		1.0E–02

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	7.6E–10	NA	NA
aroclor–1254	1.4E–11	NA	NA
aroclor–1260	NA	NA	NA
arsenic	1.1E–09	1.5E+01	1.6E–08
beryllium	1.2E–10	8.4E+00	1.0E–09
benzo(a)pyrene	3.5E–12	6.1E+00	2.1E–11
cadmium	1.1E–10	6.3E+00	6.7E–10
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	1.6E–06	NA	NA
manganese	1.4E–07	NA	NA
mercury	4.7E–11	NA	NA
silver	3.6E–10	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	2.1E–13	6.0E–03	1.3E–15
uranium–total	3.2E–09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.8E–08

Table H.V.1–42
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		20 m^3/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		70 Year
Ca	Concentration of radionuclides in air		(see table below)

Ra_{226+8d}	1.6E–06	pCi/m^3	pCi/m^3
Rn_{222}	2.2E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	2.4E–07	pCi/m^3	pCi/m^3
Tc_{99}	1.6E–07	pCi/m^3	pCi/m^3
Th_{230}	1.8E–06	pCi/m^3	pCi/m^3
$Th_{232+10d}$	7.0E–07	pCi/m^3	pCi/m^3
$U_{235/236}$	5.3E–08	pCi/m^3	pCi/m^3
U_{238+2d}	3.9E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	7.7E–01	7.0E–09	5.4E–09
Rn_{222}	1.1E+07	7.3E–13	7.9E–06
Sr_{90+1d}	1.2E–01	6.2E–11	7.2E–12
Tc_{99}	7.8E–02	8.3E–12	6.5E–13
Th_{230}	8.8E–01	2.9E–08	2.6E–08
$Th_{232+10d}$	3.4E–01	1.1E–07	3.8E–08
$U_{235/236}$	2.6E–02	2.5E–08	6.5E–10
U_{238+2d}	1.9E+00	2.4E–08	4.6E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		8.0E–06

Table H.V.1–43
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
arodor–1254	2.5E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E–01	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	6.0E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E–01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1-43 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	9.8E-06	4.0E-04	2.4E-02
aroclor-1254	6.1E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.4E-05	3.0E-04	4.7E-02
beryllium	1.6E-06	5.0E-03	3.3E-04
benzo(a)pyrene	4.9E-08	NA	NA
cadmium	1.5E-06	1.0E-03	1.5E-03
1,2-dichloroethane	NA	NA	NA
magnesium	1.2E-02	9.7E+00	1.2E-03
manganese	2.0E-03	1.4E-01	1.4E-02
mercury	5.2E-07	3.0E-04	1.7E-03
silver	4.5E-06	5.0E-03	9.1E-04
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.9E-09	6.0E-03	3.1E-07
uranium-total	2.9E-05	3.0E-03	9.5E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.0E-01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	9.8E-06	NA	NA
aroclor-1254	6.1E-08	7.7E+00	4.7E-07
aroclor-1260	NA	7.7E+00	
arsenic	1.4E-05	1.8E+00	2.5E-05
beryllium	1.6E-06	4.3E+00	7.0E-06
benzo(a)pyrene	4.9E-08	7.3E+00	3.6E-07
cadmium	1.5E-06	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	1.2E-02	NA	NA
manganese	2.0E-03	NA	NA
mercury	5.2E-07	NA	NA
silver	4.5E-06	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	1.9E-09	1.1E-02	2.0E-11
uranium-total	2.9E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		3.3E-05

000278

Table H.V.1–44
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	70 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	1.60E–03	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	3.69E–04	pCi/mg	pCi/mg
Tc_{99}	2.50E–04	pCi/mg	pCi/mg
Th_{230}	2.14E–03	pCi/mg	pCi/mg
$Th_{232+10d}$	1.11E–03	pCi/mg	pCi/mg
$U_{235/236}$	7.06E–05	pCi/mg	pCi/mg
U_{238+2d}	3.85E–03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	7.06E+03	7.80E–10	5.50E–06
Rn_{222}	NA	1.40E–12	NA
Sr_{90+1d}	1.63E+03	3.60E–11	5.86E–08
Tc_{99}	1.10E+03	1.30E–12	1.43E–09
Th_{230}	9.44E+03	1.30E–11	1.23E–07
$Th_{232+10d}$	4.90E+03	1.70E–10	8.32E–07
$U_{235/236}$	3.11E+02	1.60E–11	4.98E–09
U_{238+2d}	1.70E+04	2.00E–11	3.40E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 6.86E–06

Table H.V.1-45
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E-06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E-02	3.97E+00	mg/kg		NA	mg/kg
arodor-1254	6.00E-02	2.46E-02	mg/kg		NA	mg/kg
arodor-1260	6.00E-02		mg/kg		NA	mg/kg
arsenic	1.00E-03	5.75E+00	mg/kg		NA	mg/kg
beryllium	1.00E-02	6.62E-01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E-01	2.00E-02	mg/kg		NA	mg/kg
cadmium	1.00E-02	5.96E-01	mg/kg		NA	mg/kg
1,2-dichloroethane	3.00E-01		mg/kg		NA	mg/kg
magnesium	1.00E-02	4.75E+03	mg/kg		NA	mg/kg
manganese	1.00E-02	8.12E+02	mg/kg		NA	mg/kg
mercury	5.00E-02	2.09E-01	mg/kg		NA	mg/kg
silver	1.00E-02	1.84E+00	mg/kg		NA	mg/kg
2,3,7,8-tcdd	3.00E-02		mg/kg		NA	mg/kg
trichloroethene	3.00E-01	7.55E-04	mg/kg		NA	mg/kg
uranium-total	1.00E-02	1.16E+01	mg/kg		NA	mg/kg
	NA		mg/kg			

References

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Table H.V.1-45 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Dermal Contact with Soil

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.13E-06	6.00E-05	5.21E-02
aroclor-1254	1.16E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	4.53E-07	2.85E-04	1.59E-03
beryllium	5.21E-07	5.00E-03	1.04E-04
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	4.69E-07	5.00E-05	9.39E-03
1,2-dichloroethane	NA	NA	NA
magnesium	3.74E-03	4.85E-01	7.71E-03
manganese	6.40E-04	4.20E-03	1.52E-01
mercury	8.23E-07	4.50E-05	1.83E-02
silver	1.45E-06	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.78E-08	5.88E-03	3.03E-06
uranium-total	9.14E-06	1.50E-04	6.09E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.02E-01

Compound	TLCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	3.13E-06	NA	NA
aroclor-1254	1.16E-07	1.03E+01	1.19E-06
aroclor-1260	NA	1.03E+01	
arsenic	4.53E-07	1.84E+00	8.34E-07
beryllium	5.21E-07	4.30E+00	2.24E-06
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	4.69E-07	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	3.74E-03	NA	NA
manganese	6.40E-04	NA	NA
mercury	8.23E-07	NA	NA
silver	1.45E-06	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	1.78E-08	1.12E-02	2.00E-10
uranium-total	9.14E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.27E-06

000584

6349

Table H.V.1-46
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	6.28E-07	mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	6.69E-03	mg/l			mg/l
manganese	6.42E-02	mg/l			mg/l
mercury	2.66E-10	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	9.02E-03	mg/l			mg/l
		mg/l			

References

285000

Table H.V.1–46 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	4.00E–04	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	1.72E–08	3.00E–04	5.74E–05
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E–03	NA
1,2–dichloroethane	NA	NA	NA
magnesium	1.83E–04	9.70E+00	1.89E–05
manganese	1.76E–03	5.00E–03	3.52E–01
mercury	7.28E–12	3.00E–04	2.43E–08
silver	NA	5.00E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	6.00E–03	NA
uranium–total	2.47E–04	3.00E–03	8.24E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.34E–01

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	7.70E+00	NA
aroclor–1260	NA	7.70E+00	NA
arsenic	1.72E–08	1.75E+00	3.01E–08
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	9.10E–02	NA
magnesium	1.83E–04	NA	NA
manganese	1.76E–03	NA	NA
mercury	7.28E–12	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E–02	NA
uranium–total	2.47E–04	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		3.01E–08

000283

Table H.V.1–47
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}	5.9E–01	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	6.8E–01	pCi/l	pCi/l
Tc_{99}	3.9E+01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	2.3E–01	pCi/l	pCi/l
U_{238+2d}	3.3E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	2.9E+04	7.8E–10	2.3E–05
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	3.3E+04	3.6E–11	1.2E–06
Tc_{99}	1.9E+06	1.3E–12	2.5E–06
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	1.1E+04	1.6E–11	1.8E–07
U_{238+2d}	1.6E+05	2.0E–11	3.2E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 3.0E–05

Table II.V.1–48
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	25550	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1254	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1260	NA	mg/cm^2–day		NA	mg/cm^2–day
arsenic	1.57E–12	mg/cm^2–day		NA	mg/cm^2–day
beryllium	NA	mg/cm^2–day		NA	mg/cm^2–day
benzo(a)pyrene	NA	mg/cm^2–day		NA	mg/cm^2–day
cadmium	NA	mg/cm^2–day		NA	mg/cm^2–day
1,2–dichloroethane	NA	mg/cm^2–day		NA	mg/cm^2–day
magnesium	1.67E–08	mg/cm^2–day		NA	mg/cm^2–day
manganese	1.61E–07	mg/cm^2–day		NA	mg/cm^2–day
mercury	6.64E–16	mg/cm^2–day		NA	mg/cm^2–day
silver	NA	mg/cm^2–day		NA	mg/cm^2–day
2,3,7,8–tcdd	NA	mg/cm^2–day		NA	mg/cm^2–day
trichloroethene	NA	mg/cm^2–day		NA	mg/cm^2–day
uranium–total	2.26E–08	mg/cm^2–day		NA	mg/cm^2–day
	NA	mg/cm^2–day			

References

Table H.V.1–48 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	6.00E–05	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	4.95E–10	2.85E–04	1.74E–06
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E–05	NA
1,2–dichloroethane	NA	NA	NA
magnesium	5.27E–06	4.85E–01	1.09E–05
manganese	5.06E–05	4.20E–03	1.20E–02
mercury	2.09E–13	4.50E–05	4.65E–09
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	5.88E–03	NA
uranium–total	7.10E–06	1.50E–04	4.74E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.94E–02

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
arsenic	4.95E–10	1.84E+00	9.11E–10
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	1.01E–01	NA
magnesium	5.27E–06	NA	NA
manganese	5.06E–05	NA	NA
mercury	2.09E–13	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E–02	NA
uranium–total	7.10E–06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		9.11E–10

000286

Table H.V.1–49
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E–05	mg/kg			mg/kg
arodor–1254	7.5E–07	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	2.9E–05	mg/kg			mg/kg
beryllium	6.6E–07	mg/kg			mg/kg
benzo(a)pyrene	6.8E–07	mg/kg			mg/kg
cadmium	9.2E–06	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	1.2E+00	mg/kg			mg/kg
manganese	4.2E–03	mg/kg			mg/kg
mercury	2.4E–03	mg/kg			mg/kg
silver	1.1E–04	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.8E–10	mg/kg			mg/kg
uranium–total	2.2E–06	mg/kg			mg/kg
		mg/kg			

References

285000

Table H.V.1-49 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.3E-08	4.0E-04	1.1E-04
aroclor-1254	7.7E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.0E-08	3.0E-04	9.8E-05
beryllium	6.8E-10	5.0E-03	1.4E-07
benzo(a)pyrene	7.0E-10	NA	NA
cadmium	9.4E-09	1.0E-03	9.4E-06
1,2-dichloroethane	NA	NA	NA
magnesium	1.2E-03	9.7E+00	1.3E-04
manganese	4.3E-06	1.4E-01	3.1E-05
mercury	2.4E-06	3.0E-04	8.1E-03
silver	1.2E-07	5.0E-03	2.3E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.9E-13	6.0E-03	6.5E-11
uranium-total	2.3E-09	3.0E-03	7.7E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		8.5E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	4.3E-08	NA	NA
aroclor-1254	7.7E-10	7.7E+00	5.9E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	3.0E-08	1.8E+00	5.2E-08
beryllium	6.8E-10	4.3E+00	2.9E-09
benzo(a)pyrene	7.0E-10	7.3E+00	5.1E-09
cadmium	9.4E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.2E-03	NA	NA
manganese	4.3E-06	NA	NA
mercury	2.4E-06	NA	NA
silver	1.2E-07	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.9E-13	1.1E-02	4.3E-15
uranium-total	2.3E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		6.6E-08

000588

Table H.V.1-50
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	5.1E-04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	1.4E-02	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	7.0E-06	pCi/kg	pCi/kg
$Th_{232+10d}$	3.6E-06	pCi/kg	pCi/kg
$U_{235/236}$	1.5E-05	pCi/kg	pCi/kg
U_{238+2d}	7.5E-04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	9.3E-01	7.8E-10	7.3E-10
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	2.6E+01	3.6E-11	9.2E-10
Tc_{99}	1.9E+03	1.3E-12	2.5E-09
Th_{230}	1.3E-02	1.3E-11	1.7E-13
$Th_{232+10d}$	6.6E-03	1.7E-10	1.1E-12
$U_{235/236}$	2.8E-02	1.6E-11	4.5E-13
U_{238+2d}	1.4E+00	2.0E-11	2.7E-11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 4.1E-09

Table II.V.1–51
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E–03	mg/kg			mg/kg
arodor–1254	2.4E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	8.6E–04	mg/kg			mg/kg
beryllium	6.0E–07	mg/kg			mg/kg
benzo(a)pyrene	2.2E–04	mg/kg			mg/kg
cadmium	1.7E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	9.6E+02	mg/kg			mg/kg
manganese	3.7E+00	mg/kg			mg/kg
mercury	4.3E–03	mg/kg			mg/kg
silver	7.5E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	1.2E–07	mg/kg			mg/kg
uranium–total	6.8E–03	mg/kg			mg/kg
		mg/kg			

References

005530

Table H.V.1-51 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.7E-05	4.0E-04	4.3E-02
aroclor-1254	9.7E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.5E-06	3.0E-04	1.2E-02
beryllium	2.4E-09	5.0E-03	4.9E-07
benzo(a)pyrene	8.8E-07	NA	NA
cadmium	6.9E-05	1.0E-03	6.9E-02
1,2-dichloroethane	NA	NA	NA
magnesium	3.9E+00	9.7E+00	4.1E-01
manganese	1.5E-02	1.4E-01	1.1E-01
mercury	1.8E-05	3.0E-04	5.9E-02
silver	3.1E-03	5.0E-03	6.2E-01
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-10	6.0E-03	8.2E-08
uranium-total	2.8E-05	3.0E-03	9.3E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.3E+00

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.7E-05	NA	NA
aroclor-1254	9.7E-07	7.7E+00	7.5E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	3.5E-06	1.8E+00	6.2E-06
beryllium	2.4E-09	4.3E+00	1.1E-08
benzo(a)pyrene	8.8E-07	7.3E+00	6.5E-06
cadmium	6.9E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	3.9E+00	NA	NA
manganese	1.5E-02	NA	NA
mercury	1.8E-05	NA	NA
silver	3.1E-03	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.9E-10	1.1E-02	5.4E-12
uranium-total	2.8E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		2.0E-05

0063594

Table H.V.1–52
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	9.2E–01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	7.0E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	5.8E–03	pCi/kg	pCi/kg
$Th_{232+10d}$	3.0E–03	pCi/kg	pCi/kg
$U_{235/236}$	4.7E–02	pCi/kg	pCi/kg
U_{238+2d}	2.3E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	6.7E+03	7.8E–10	5.3E–06
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	5.1E+05	3.6E–11	1.8E–05
Tc_{99}	8.9E+06	1.3E–12	1.2E–05
Th_{230}	4.3E+01	1.3E–11	5.5E–10
$Th_{232+10d}$	2.2E+01	1.7E–10	3.8E–09
$U_{235/236}$	3.5E+02	1.6E–11	5.6E–09
U_{238+2d}	1.7E+04	2.0E–11	3.3E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 3.6E–05

Table H.V.1–53
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units
antimony	7.9E–01	mg/kg
arodor–1254	3.1E–04	mg/kg
arodor–1260		mg/kg
arsenic	2.3E–01	mg/kg
beryllium	6.6E–03	mg/kg
benzo(a)pyrene	2.3E–04	mg/kg
cadmium	3.3E–01	mg/kg
1,2–dichloroethane		mg/kg
magnesium	4.8E+03	mg/kg
manganese	2.0E+02	mg/kg
mercury	1.9E–01	mg/kg
silver	7.4E–01	mg/kg
2,3,7,8–tcdd		mg/kg
trichloroethene	1.2E–03	mg/kg
uranium–total	1.4E–01	mg/kg
		mg/kg

Compound	Concentration	Units
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg

References

000593

Table H.V.1-53 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	6.6E-04	4.0E-04	1.7E+00
aroclor-1254	2.6E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.9E-04	3.0E-04	6.4E-01
beryllium	5.5E-06	5.0E-03	1.1E-03
benzo(a)pyrene	1.9E-07	NA	NA
cadmium	2.7E-04	1.0E-03	2.7E-01
1,2-dichloroethane	NA	NA	NA
magnesium	4.0E+00	9.7E+00	4.1E-01
manganese	1.7E-01	1.4E-01	1.2E+00
mercury	1.6E-04	3.0E-04	5.2E-01
silver	6.2E-04	5.0E-03	1.2E-01
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.0E-06	6.0E-03	1.7E-04
uranium-total	1.2E-04	3.0E-03	4.0E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.9E+00

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	6.6E-04	NA	NA
aroclor-1254	2.6E-07	7.7E+00	2.0E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	1.9E-04	1.8E+00	3.4E-04
beryllium	5.5E-06	4.3E+00	2.4E-05
benzo(a)pyrene	1.9E-07	7.3E+00	1.4E-06
cadmium	2.7E-04	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	4.0E+00	NA	NA
manganese	1.7E-01	NA	NA
mercury	1.6E-04	NA	NA
silver	6.2E-04	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.0E-06	1.1E-02	1.1E-08
uranium-total	1.2E-04	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		3.6E-04

005594

Table H.V.1–54
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	2.7E+01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	9.3E+02	pCi/kg	pCi/kg
Tc_{99}	2.6E+03	pCi/kg	pCi/kg
Th_{230}	1.8E+00	pCi/kg	pCi/kg
$Th_{232+10d}$	9.4E–01	pCi/kg	pCi/kg
$U_{235/236}$	1.7E+00	pCi/kg	pCi/kg
U_{238+2d}	4.9E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	4.0E+04	7.8E–10	3.1E–05
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.4E+06	3.6E–11	5.0E–05
Tc_{99}	3.9E+06	1.3E–12	5.1E–06
Th_{230}	2.7E+03	1.3E–11	3.5E–08
$Th_{232+10d}$	1.4E+03	1.7E–10	2.4E–07
$U_{235/236}$	2.6E+03	1.6E–11	4.1E–08
U_{238+2d}	7.3E+04	2.0E–11	1.5E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 8.8E–05

Table H.V.1–55
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	70 Year
ET_i	Fraction of day spent indoors	0.76 (unitless)
ET_o	Fraction of day spent outdoors	0.24 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	1.60E+00	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	3.69E–01	pCi/g	NA	pCi/g
Tc_{99}	2.50E–01	pCi/g	NA	pCi/g
Th_{230}	2.14E+00	pCi/g	NA	pCi/g
$Th_{232+10d}$	1.11E+00	pCi/g	NA	pCi/g
$U_{235/236}$	7.06E–02	pCi/g	NA	pCi/g
U_{238+2d}	3.85E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	TLCR (unitless)
Ra_{226+8d}	6.7E+01	6.0E–06	4.0E–04
Rn_{222}	NA	1.2E–09	NA
Sr_{90+1d}	1.5E+01	NA	
Tc_{99}	1.0E+01	6.0E–13	6.2E–12
Th_{230}	8.9E+01	5.4E–11	4.8E–09
$Th_{232+10d}$	4.6E+01	8.5E–06	3.9E–04
$U_{235/236}$	2.9E+00	2.4E–07	7.1E–07
U_{238+2d}	1.6E+02	5.1E–08	8.2E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation		=	8.0E–04

Table H.V.1–56
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.8E–09	mg/m^3			mg/m^3
aroclor–1254	5.3E–11	mg/m^3			mg/m^3
aroclor–1260		mg/m^3			mg/m^3
arsenic	3.9E–09	mg/m^3			mg/m^3
beryllium	4.6E–10	mg/m^3			mg/m^3
benzo(a)pyrene	1.3E–11	mg/m^3			mg/m^3
cadmium	3.9E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	5.7E–06	mg/m^3			mg/m^3
manganese	5.2E–07	mg/m^3			mg/m^3
mercury	1.7E–10	mg/m^3			mg/m^3
silver	1.3E–09	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	7.7E–13	mg/m^3			mg/m^3
uranium–total	1.2E–08	mg/m^3			mg/m^3
		mg/m^3			

References

Table H.V.1–56 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	2.1E–09	NA	NA
aroclor–1254	4.0E–11	NA	NA
aroclor–1260	NA	NA	NA
arsenic	3.0E–09	NA	NA
beryllium	3.5E–10	NA	NA
benzo(a)pyrene	9.8E–12	NA	NA
cadmium	3.0E–10	NA	NA
1,2–dichloroethane	NA	2.9E–03	NA
magnesium	4.4E–06	NA	NA
manganese	4.0E–07	1.4E–05	2.8E–02
mercury	1.3E–10	8.6E–05	1.5E–06
silver	1.0E–09	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	5.9E–13	NA	NA
uranium–total	8.9E–09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		2.8E–02

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	1.8E–10	NA	NA
aroclor–1254	3.5E–12	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.5E–10	1.5E+01	3.8E–09
beryllium	3.0E–11	8.4E+00	2.5E–10
benzo(a)pyrene	8.4E–13	6.1E+00	5.1E–12
cadmium	2.6E–11	6.3E+00	1.6E–10
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	3.8E–07	NA	NA
manganese	3.4E–08	NA	NA
mercury	1.1E–11	NA	NA
silver	8.7E–11	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	5.1E–14	6.0E–03	3.0E–16
uranium–total	7.6E–10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.2E–09

0005398

Table H.V.1–57
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		12 m^3/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		6 Year
Ca	Concentration of radionuclides in air		(see table below)
Ra_{226+8d}	1.6E–06	pCi/m^3	pCi/m^3
Rn_{222}	2.2E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	2.4E–07	pCi/m^3	pCi/m^3
Tc_{99}	1.6E–07	pCi/m^3	pCi/m^3
Th_{230}	1.8E–06	pCi/m^3	pCi/m^3
$Th_{232+10d}$	7.0E–07	pCi/m^3	pCi/m^3
$U_{235/236}$	5.3E–08	pCi/m^3	pCi/m^3
U_{238+2d}	3.9E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	4.0E–02	7.0E–09	2.8E–10
Rn_{222}	5.5E+05	7.3E–13	4.0E–07
Sr_{90+1d}	6.0E–03	6.2E–11	3.7E–13
Tc_{99}	4.0E–03	8.3E–12	3.3E–14
Th_{230}	4.5E–02	2.9E–08	1.3E–09
$Th_{232+10d}$	1.8E–02	1.1E–07	1.9E–09
$U_{235/236}$	1.3E–03	2.5E–08	3.3E–11
U_{238+2d}	9.8E–02	2.4E–08	2.3E–09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		4.1E–07

Table H.V.1–58
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
arodor–1254	2.5E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E–01	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	6.0E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E–01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

000250

Table H.V.1-58 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.1E-05	4.0E-04	1.3E-01
aroclor-1254	3.1E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	7.4E-05	3.0E-04	2.5E-01
beryllium	8.5E-06	5.0E-03	1.7E-03
benzo(a)pyrene	2.6E-07	NA	NA
cadmium	7.6E-06	1.0E-03	7.6E-03
1,2-dichloroethane	NA	NA	NA
magnesium	6.1E-02	9.7E+00	6.3E-03
manganese	1.0E-02	1.4E-01	7.4E-02
mercury	2.7E-06	3.0E-04	8.9E-03
silver	2.4E-05	5.0E-03	4.7E-03
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	9.7E-09	6.0E-03	1.6E-06
uranium-total	1.5E-04	3.0E-03	4.9E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.2E-01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	4.4E-06	NA	NA
aroclor-1254	2.7E-08	7.7E+00	2.1E-07
aroclor-1260	NA	7.7E+00	
arsenic	6.3E-06	1.8E+00	1.1E-05
beryllium	7.3E-07	4.3E+00	3.1E-06
benzo(a)pyrene	2.2E-08	7.3E+00	1.6E-07
cadmium	6.5E-07	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	5.2E-03	NA	NA
manganese	8.9E-04	NA	NA
mercury	2.3E-07	NA	NA
silver	2.0E-06	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	8.3E-10	1.1E-02	9.1E-12
uranium-total	1.3E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.5E-05

000504
6349

Table H.V.1-59
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	6 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	1.60E-03	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	3.69E-04	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	2.14E-03	pCi/mg	pCi/mg
$Th_{232+10d}$	1.11E-03	pCi/mg	pCi/mg
$U_{235/236}$	7.06E-05	pCi/mg	pCi/mg
U_{238+2d}	3.85E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	6.72E+02	7.80E-10	5.24E-07
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	1.55E+02	3.60E-11	5.58E-09
Tc_{99}	1.05E+02	1.30E-12	1.37E-10
Th_{230}	8.99E+02	1.30E-11	1.17E-08
$Th_{232+10d}$	4.66E+02	1.70E-10	7.93E-08
$U_{235/236}$	2.97E+01	1.60E-11	4.74E-10
U_{238+2d}	1.62E+03	2.00E-11	3.23E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		6.54E-07

Table H.V.1–60
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	2000	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	2190	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E–02	3.97E+00	mg/kg		NA	mg/kg
arodor–1254	6.00E–02	2.46E–02	mg/kg		NA	mg/kg
arodor–1260	6.00E–02		mg/kg		NA	mg/kg
arsenic	1.00E–03	5.75E+00	mg/kg		NA	mg/kg
beryllium	1.00E–02	6.62E–01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E–01	2.00E–02	mg/kg		NA	mg/kg
cadmium	1.00E–02	5.96E–01	mg/kg		NA	mg/kg
1,2–dichloroethane	3.00E–01		mg/kg		NA	mg/kg
magnesium	1.00E–02	4.75E+03	mg/kg		NA	mg/kg
manganese	1.00E–02	8.12E+02	mg/kg		NA	mg/kg
mercury	5.00E–02	2.09E–01	mg/kg		NA	mg/kg
silver	1.00E–02	1.84E+00	mg/kg		NA	mg/kg
2,3,7,8–tcdd	3.00E–02		mg/kg		NA	mg/kg
trichloroethene	3.00E–01	7.55E–04	mg/kg		NA	mg/kg
uranium–total	1.00E–02	1.16E+01	mg/kg		NA	mg/kg
	NA		mg/kg			

References

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Table H.V.1-60 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.08E-06	6.00E-05	8.46E-02
aroclor-1254	1.89E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	7.35E-07	2.85E-04	2.58E-03
beryllium	8.46E-07	5.00E-03	1.69E-04
benzo(a)pyrene	7.67E-07	NA	NA
cadmium	7.62E-07	5.00E-05	1.52E-02
1,2-dichloroethane	NA	NA	NA
magnesium	6.07E-03	4.85E-01	1.25E-02
manganese	1.04E-03	4.20E-03	2.47E-01
mercury	1.34E-06	4.50E-05	2.97E-02
silver	2.35E-06	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.90E-08	5.88E-03	4.92E-06
uranium-total	1.48E-05	1.50E-04	9.89E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.91E-01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	4.35E-07	NA	NA
aroclor-1254	1.62E-08	1.03E+01	1.66E-07
aroclor-1260	NA	1.03E+01	
arsenic	6.30E-08	1.84E+00	1.16E-07
beryllium	7.25E-08	4.30E+00	3.12E-07
benzo(a)pyrene	6.58E-08	NA	NA
cadmium	6.53E-08	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	5.21E-04	NA	NA
manganese	8.90E-05	NA	NA
mercury	1.15E-07	NA	NA
silver	2.02E-07	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	2.48E-09	1.12E-02	2.79E-11
uranium-total	1.27E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		5.94E-07

Table H.V.1–61
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor–1254		mg/l			mg/l
arodor–1260		mg/l			mg/l
arsenic	6.28E–07	mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2–dichloroethane		mg/l			mg/l
magnesium	6.69E–03	mg/l			mg/l
manganese	6.42E–02	mg/l			mg/l
mercury	2.66E–10	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8–tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium–total	9.02E–03	mg/l			mg/l
		mg/l			

References

Table H.V.1-61 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.00E-04	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	4.02E-08	3.00E-04	1.34E-04
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	4.28E-04	9.70E+00	4.41E-05
manganese	4.10E-03	5.00E-03	8.21E-01
mercury	1.70E-11	3.00E-04	5.66E-08
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	5.77E-04	3.00E-03	1.92E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			1.01E+00

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	3.44E-09	1.75E+00	6.02E-09
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	3.67E-05	NA	NA
manganese	3.52E-04	NA	NA
mercury	1.46E-12	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	4.94E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			6.02E-09

005000

Table H.V.1–62
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}	5.9E–01	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	6.8E–01	pCi/l	pCi/l
Tc_{99}	3.9E+01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	2.3E–01	pCi/l	pCi/l
U_{238+2d}	3.3E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.2E+03	7.8E–10	9.7E–07
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.4E+03	3.6E–11	5.1E–08
Tc_{99}	8.1E+04	1.3E–12	1.1E–07
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	4.8E+02	1.6E–11	7.6E–09
U_{238+2d}	7.0E+03	2.0E–11	1.4E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 1.3E–06

Table H.V.1–63
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	2190	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1254	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1260	NA	mg/cm^2–day		NA	mg/cm^2–day
arsenic	1.57E–12	mg/cm^2–day		NA	mg/cm^2–day
beryllium	NA	mg/cm^2–day		NA	mg/cm^2–day
benzo(a)pyrene	NA	mg/cm^2–day		NA	mg/cm^2–day
cadmium	NA	mg/cm^2–day		NA	mg/cm^2–day
1,2–dichloroethane	NA	mg/cm^2–day		NA	mg/cm^2–day
magnesium	1.67E–08	mg/cm^2–day		NA	mg/cm^2–day
manganese	1.61E–07	mg/cm^2–day		NA	mg/cm^2–day
mercury	6.64E–16	mg/cm^2–day		NA	mg/cm^2–day
silver	NA	mg/cm^2–day		NA	mg/cm^2–day
2,3,7,8–tcdd	NA	mg/cm^2–day		NA	mg/cm^2–day
trichloroethene	NA	mg/cm^2–day		NA	mg/cm^2–day
uranium–total	2.26E–08	mg/cm^2–day		NA	mg/cm^2–day
	NA	mg/cm^2–day			

References

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Table H.V.1-63 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	6.00E-05	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.31E-09	2.85E-04	8.10E-06
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	2.46E-05	4.85E-01	5.07E-05
manganese	2.36E-04	4.20E-03	5.62E-02
mercury	9.76E-13	4.50E-05	2.17E-08
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	3.32E-05	1.50E-04	2.21E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.77E-01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	1.98E-10	1.84E+00	3.65E-10
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	2.11E-06	NA	NA
manganese	2.02E-05	NA	NA
mercury	8.37E-14	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	2.84E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		3.65E-10

000609

Table H.V.1-64
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E-05	mg/kg			mg/kg
arodor-1254	7.5E-07	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	2.9E-05	mg/kg			mg/kg
beryllium	6.6E-07	mg/kg			mg/kg
benzo(a)pyrene	6.8E-07	mg/kg			mg/kg
cadmium	9.2E-06	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	1.2E+00	mg/kg			mg/kg
manganese	4.2E-03	mg/kg			mg/kg
mercury	2.4E-03	mg/kg			mg/kg
silver	1.1E-04	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.8E-10	mg/kg			mg/kg
uranium-total	2.2E-06	mg/kg			mg/kg
		mg/kg			

References

003240

Table H.V.1–64 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	7.8E–08	4.0E–04	1.9E–04
aroclor–1254	1.4E–09	NA	NA
aroclor–1260	NA	NA	NA
arsenic	5.4E–08	3.0E–04	1.8E–04
beryllium	1.2E–09	5.0E–03	2.5E–07
benzo(a)pyrene	1.3E–09	NA	NA
cadmium	1.7E–08	1.0E–03	1.7E–05
1,2–dichloroethane	NA	NA	NA
magnesium	2.2E–03	9.7E+00	2.3E–04
manganese	7.9E–06	1.4E–01	5.6E–05
mercury	4.4E–06	3.0E–04	1.5E–02
silver	2.1E–07	5.0E–03	4.2E–05
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	7.1E–13	6.0E–03	1.2E–10
uranium–total	4.2E–09	3.0E–03	1.4E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.6E–02

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	6.7E–09	NA	NA
aroclor–1254	1.2E–10	7.7E+00	9.3E–10
aroclor–1260	NA	7.7E+00	NA
arsenic	4.6E–09	1.8E+00	8.1E–09
beryllium	1.1E–10	4.3E+00	4.6E–10
benzo(a)pyrene	1.1E–10	7.3E+00	7.9E–10
cadmium	1.5E–09	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	1.9E–04	NA	NA
manganese	6.8E–07	NA	NA
mercury	3.8E–07	NA	NA
silver	1.8E–08	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	6.0E–14	1.1E–02	6.7E–16
uranium–total	3.6E–10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.0E–08

006674

Table H.V.1–65
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	5.1E–04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	1.4E–02	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	7.0E–06	pCi/kg	pCi/kg
$Th_{232+10d}$	3.6E–06	pCi/kg	pCi/kg
$U_{235/236}$	1.5E–05	pCi/kg	pCi/kg
U_{238+2d}	7.5E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	3.1E–02	7.8E–10	2.4E–11
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	8.5E–01	3.6E–11	3.1E–11
Tc_{99}	6.3E+01	1.3E–12	8.2E–11
Th_{230}	4.3E–04	1.3E–11	5.6E–15
$Th_{232+10d}$	2.2E–04	1.7E–10	3.8E–14
$U_{235/236}$	9.4E–04	1.6E–11	1.5E–14
U_{238+2d}	4.6E–02	2.0E–11	9.2E–13
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 1.4E–10

Table H.V.1–66
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units
antimony	4.2E–03	mg/kg
arodor–1254	2.4E–04	mg/kg
arodor–1260		mg/kg
arsenic	8.6E–04	mg/kg
beryllium	6.0E–07	mg/kg
benzo(a)pyrene	2.2E–04	mg/kg
cadmium	1.7E–02	mg/kg
1,2–dichloroethane		mg/kg
magnesium	9.6E+02	mg/kg
manganese	3.7E+00	mg/kg
mercury	4.3E–03	mg/kg
silver	7.5E–01	mg/kg
2,3,7,8–tcdd		mg/kg
trichloroethene	1.2E–07	mg/kg
uranium–total	6.8E–03	mg/kg
		mg/kg

Compound	Concentration	Units
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg

References

000543

Table H.V.1-66 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.8E-04	4.0E-04	4.5E-01
aroclor-1254	1.0E-05	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.7E-05	3.0E-04	1.2E-01
beryllium	2.6E-08	5.0E-03	5.1E-06
benzo(a)pyrene	9.3E-06	NA	NA
cadmium	7.2E-04	1.0E-03	7.2E-01
1,2-dichloroethane	NA	NA	NA
magnesium	4.1E+01	9.7E+00	4.3E+00
manganese	1.6E-01	1.4E-01	1.1E+00
mercury	1.8E-04	3.0E-04	6.2E-01
silver	3.3E-02	5.0E-03	6.5E+00
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	5.2E-09	6.0E-03	8.6E-07
uranium-total	2.9E-04	3.0E-03	9.7E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.4E+01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.5E-05	NA	NA
aroclor-1254	8.8E-07	7.7E+00	6.8E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	3.2E-06	1.8E+00	5.6E-06
beryllium	2.2E-09	4.3E+00	9.5E-09
benzo(a)pyrene	8.0E-07	7.3E+00	5.8E-06
cadmium	6.2E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	3.5E+00	NA	NA
manganese	1.4E-02	NA	NA
mercury	1.6E-05	NA	NA
silver	2.8E-03	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.4E-10	1.1E-02	4.9E-12
uranium-total	2.5E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.8E-05

000644

Table H.V.1–67
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	9.2E–01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	7.0E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	5.8E–03	pCi/kg	pCi/kg
$Th_{232+10d}$	3.0E–03	pCi/kg	pCi/kg
$U_{235/236}$	4.7E–02	pCi/kg	pCi/kg
U_{238+2d}	2.3E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.3E+03	7.8E–10	1.0E–06
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	9.9E+04	3.6E–11	3.5E–06
Tc_{99}	1.7E+06	1.3E–12	2.2E–06
Th_{230}	8.2E+00	1.3E–11	1.1E–10
$Th_{232+10d}$	4.3E+00	1.7E–10	7.3E–10
$U_{235/236}$	6.7E+01	1.6E–11	1.1E–09
U_{238+2d}	3.2E+03	2.0E–11	6.4E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 6.9E–06

Table H.V.1-68
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.9E-01	mg/kg			mg/kg
arodor-1254	3.1E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	2.3E-01	mg/kg			mg/kg
beryllium	6.6E-03	mg/kg			mg/kg
benzo(a)pyrene	2.3E-04	mg/kg			mg/kg
cadmium	3.3E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	2.0E+02	mg/kg			mg/kg
mercury	1.9E-01	mg/kg			mg/kg
silver	7.4E-01	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	1.2E-03	mg/kg			mg/kg
uranium-total	1.4E-01	mg/kg			mg/kg
		mg/kg			

References

000576

Table H.V.1–68 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	2.7E–03	4.0E–04	6.7E+00
aroclor–1254	1.1E–06	NA	NA
aroclor–1260	NA	NA	NA
arsenic	7.8E–04	3.0E–04	2.6E+00
beryllium	2.2E–05	5.0E–03	4.5E–03
benzo(a)pyrene	7.8E–07	NA	NA
cadmium	1.1E–03	1.0E–03	1.1E+00
1,2–dichloroethane	NA	NA	NA
magnesium	1.6E+01	9.7E+00	1.7E+00
manganese	6.9E–01	1.4E–01	4.9E+00
mercury	6.4E–04	3.0E–04	2.1E+00
silver	2.5E–03	5.0E–03	5.0E–01
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	4.1E–06	6.0E–03	6.8E–04
uranium–total	4.8E–04	3.0E–03	1.6E–01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.0E+01

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	2.3E–04	NA	NA
aroclor–1254	9.1E–08	7.7E+00	7.0E–07
aroclor–1260	NA	7.7E+00	NA
arsenic	6.7E–05	1.8E+00	1.2E–04
beryllium	1.9E–06	4.3E+00	8.3E–06
benzo(a)pyrene	6.7E–08	7.3E+00	4.9E–07
cadmium	9.5E–05	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	1.4E+00	NA	NA
manganese	5.9E–02	NA	NA
mercury	5.5E–05	NA	NA
silver	2.1E–04	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	3.5E–07	1.1E–02	3.8E–09
uranium–total	4.1E–05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.3E–04

0006347

Table H.V.1–69
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	2.7E+01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	9.3E+02	pCi/kg	pCi/kg
Tc_{99}	2.6E+03	pCi/kg	pCi/kg
Th_{230}	1.8E+00	pCi/kg	pCi/kg
$Th_{232+10d}$	9.4E–01	pCi/kg	pCi/kg
$U_{235/236}$	1.7E+00	pCi/kg	pCi/kg
U_{238+2d}	4.9E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	3.0E+03	7.8E–10	2.3E–06
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.0E+05	3.6E–11	3.7E–06
Tc_{99}	2.9E+05	1.3E–12	3.8E–07
Th_{230}	2.0E+02	1.3E–11	2.6E–09
$Th_{232+10d}$	1.1E+02	1.7E–10	1.8E–08
$U_{235/236}$	1.9E+02	1.6E–11	3.0E–09
U_{238+2d}	5.4E+03	2.0E–11	1.1E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 6.6E–06

Table H.V.1–70
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	6 Year
ET_i	Fraction of day spent indoors	0.92 (unitless)
ET_o	Fraction of day spent outdoors	0.08 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	1.60E+00	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	3.69E–01	pCi/g	NA	pCi/g
Tc_{99}	2.50E–01	pCi/g	NA	pCi/g
Th_{230}	2.14E+00	pCi/g	NA	pCi/g
$Th_{232+10d}$	1.11E+00	pCi/g	NA	pCi/g
$U_{235/236}$	7.06E–02	pCi/g	NA	pCi/g
U_{238+2d}	3.85E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	TLCR (unitless)
Ra_{226+8d}	5.0E+00	6.0E–06	3.0E–05
Rn_{222}	NA	1.2E–09	NA
Sr_{90+1d}	1.1E+00	NA	
Tc_{99}	7.8E–01	6.0E–13	4.7E–13
Th_{230}	6.7E+00	5.4E–11	3.6E–10
$Th_{232+10d}$	3.5E+00	8.5E–06	2.9E–05
$U_{235/236}$	2.2E–01	2.4E–07	5.3E–08
U_{238+2d}	1.2E+01	5.1E–08	6.1E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation		=	6.0E–05

Table II.V.1-71
Summary of Risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E-05	mg/kg			mg/kg
arodor-1254	7.5E-07	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	2.9E-05	mg/kg			mg/kg
beryllium	6.6E-07	mg/kg			mg/kg
benzo(a)pyrene	6.8E-07	mg/kg			mg/kg
cadmium	9.2E-06	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	1.2E+00	mg/kg			mg/kg
manganese	4.2E-03	mg/kg			mg/kg
mercury	2.4E-03	mg/kg			mg/kg
silver	1.1E-04	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.8E-10	mg/kg			mg/kg
uranium-total	2.2E-06	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1-71 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.3E-08	4.0E-04	1.1E-04
aroclor-1254	7.7E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.0E-08	3.0E-04	9.8E-05
beryllium	6.8E-10	5.0E-03	1.4E-07
benzo(a)pyrene	7.0E-10	NA	NA
cadmium	9.4E-09	1.0E-03	9.4E-06
1,2-dichloroethane	NA	NA	NA
magnesium	1.2E-03	9.7E+00	1.3E-04
manganese	4.3E-06	1.4E-01	3.1E-05
mercury	2.4E-06	3.0E-04	8.1E-03
silver	1.2E-07	5.0E-03	2.3E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.9E-13	6.0E-03	6.5E-11
uranium-total	2.3E-09	3.0E-03	7.7E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			8.5E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	4.3E-08	NA	NA
aroclor-1254	7.7E-10	7.7E+00	5.9E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	3.0E-08	1.8E+00	5.2E-08
beryllium	6.8E-10	4.3E+00	2.9E-09
benzo(a)pyrene	7.0E-10	7.3E+00	5.1E-09
cadmium	9.4E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.2E-03	NA	NA
manganese	4.3E-06	NA	NA
mercury	2.4E-06	NA	NA
silver	1.2E-07	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.9E-13	1.1E-02	4.3E-15
uranium-total	2.3E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			6.6E-08

Table H.V.1−72
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	5.1E−04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	1.4E−02	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	7.0E−06	pCi/kg	pCi/kg
$Th_{232+10d}$	3.6E−06	pCi/kg	pCi/kg
$U_{235/236}$	1.5E−05	pCi/kg	pCi/kg
U_{238+2d}	7.5E−04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	9.3E−01	7.8E−10	7.3E−10
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	2.6E+01	3.6E−11	9.2E−10
Tc_{99}	1.9E+03	1.3E−12	2.5E−09
Th_{230}	1.3E−02	1.3E−11	1.7E−13
$Th_{232+10d}$	6.6E−03	1.7E−10	1.1E−12
$U_{235/236}$	2.8E−02	1.6E−11	4.5E−13
U_{238+2d}	1.4E+00	2.0E−11	2.7E−11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
		TLCR Summation =	4.1E−09

Table H.V.1–73
Summary of Risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E–03	mg/kg			mg/kg
arodor–1254	2.4E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	8.6E–04	mg/kg			mg/kg
beryllium	6.0E–07	mg/kg			mg/kg
benzo(a)pyrene	2.2E–04	mg/kg			mg/kg
cadmium	1.7E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	9.6E+02	mg/kg			mg/kg
manganese	3.7E+00	mg/kg			mg/kg
mercury	4.3E–03	mg/kg			mg/kg
silver	7.5E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	1.2E–07	mg/kg			mg/kg
uranium–total	6.8E–03	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1-73 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.7E-05	4.0E-04	4.3E-02
aroclor-1254	9.7E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.5E-06	3.0E-04	1.2E-02
beryllium	2.4E-09	5.0E-03	4.9E-07
benzo(a)pyrene	8.8E-07	NA	NA
cadmium	6.9E-05	1.0E-03	6.9E-02
1,2-dichloroethane	NA	NA	NA
magnesium	3.9E+00	9.7E+00	4.1E-01
manganese	1.5E-02	1.4E-01	1.1E-01
mercury	1.8E-05	3.0E-04	5.9E-02
silver	3.1E-03	5.0E-03	6.2E-01
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-10	6.0E-03	8.2E-08
uranium-total	2.8E-05	3.0E-03	9.3E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			1.3E+00

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.7E-05	NA	NA
aroclor-1254	9.7E-07	7.7E+00	7.5E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	3.5E-06	1.8E+00	6.2E-06
beryllium	2.4E-09	4.3E+00	1.1E-08
benzo(a)pyrene	8.8E-07	7.3E+00	6.5E-06
cadmium	6.9E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	3.9E+00	NA	NA
manganese	1.5E-02	NA	NA
mercury	1.8E-05	NA	NA
silver	3.1E-03	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.9E-10	1.1E-02	5.4E-12
uranium-total	2.8E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			2.0E-05

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Table H.V.1–74
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	9.2E−01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	7.0E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	5.8E−03	pCi/kg	pCi/kg
$Th_{232+10d}$	3.0E−03	pCi/kg	pCi/kg
$U_{235/236}$	4.7E−02	pCi/kg	pCi/kg
U_{238+2d}	2.3E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	6.7E+03	7.8E−10	5.3E−06
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	5.1E+05	3.6E−11	1.8E−05
Tc_{99}	8.9E+06	1.3E−12	1.2E−05
Th_{230}	4.3E+01	1.3E−11	5.5E−10
$Th_{232+10d}$	2.2E+01	1.7E−10	3.8E−09
$U_{235/236}$	3.5E+02	1.6E−11	5.6E−09
U_{238+2d}	1.7E+04	2.0E−11	3.3E−07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		3.6E−05

Table H.V.1–75
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non–carcinogens	25 Year
EDc	Exposure duration for carcinogens	25 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.0E–09	mg/m^3			mg/m^3
arodor–1254	1.6E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	3.2E–09	mg/m^3			mg/m^3
beryllium	3.5E–10	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E–11	mg/m^3			mg/m^3
cadmium	3.0E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	1.8E–06	mg/m^3			mg/m^3
manganese	4.5E–07	mg/m^3			mg/m^3
mercury	1.5E–10	mg/m^3			mg/m^3
silver	1.1E–09	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E–13	mg/m^3			mg/m^3
uranium–total	1.1E–08	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.V.1-75 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.0E-10	NA	NA
aroclor-1254	3.1E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.2E-10	NA	NA
beryllium	6.8E-11	NA	NA
benzo(a)pyrene	2.2E-12	NA	NA
cadmium	5.9E-11	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	3.6E-07	NA	NA
manganese	8.7E-08	1.4E-05	6.1E-03
mercury	2.9E-11	8.6E-05	3.4E-07
silver	2.2E-10	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	8.6E-14	NA	NA
uranium-total	2.1E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		6.1E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.4E-10	NA	NA
aroclor-1254	1.1E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.2E-10	1.5E+01	3.3E-09
beryllium	2.4E-11	8.4E+00	2.0E-10
benzo(a)pyrene	7.8E-13	6.1E+00	4.7E-12
cadmium	2.1E-11	6.3E+00	1.3E-10
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.3E-07	NA	NA
manganese	3.1E-08	NA	NA
mercury	1.0E-11	NA	NA
silver	7.9E-11	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.1E-14	6.0E-03	1.9E-16
uranium-total	7.5E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		3.7E-09

Table H.V.1-76
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Commercial/Industrial User
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	250 days/year
EDn	Exposure duration	25 Year
Ca	Concentration of radionuclides in air	(see table below)

Ra_{226+8d}	8.2E-07	pCi/m^3	pCi/m^3
Rn_{222}	1.1E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	1.9E-07	pCi/m^3	pCi/m^3
Tc_{99}	1.4E-07	pCi/m^3	pCi/m^3
Th_{230}	1.3E-06	pCi/m^3	pCi/m^3
$Th_{232+10d}$	6.0E-07	pCi/m^3	pCi/m^3
$U_{235/236}$	4.7E-08	pCi/m^3	pCi/m^3
U_{238+2d}	3.6E-06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.0E-01	7.0E-09	7.1E-10
Rn_{222}	1.4E+06	7.3E-13	1.0E-06
Sr_{90+1d}	2.3E-02	6.2E-11	1.4E-12
Tc_{99}	1.7E-02	8.3E-12	1.4E-13
Th_{230}	1.6E-01	2.9E-08	4.5E-09
$Th_{232+10d}$	7.5E-02	1.1E-07	8.3E-09
$U_{235/236}$	5.8E-03	2.5E-08	1.5E-10
U_{238+2d}	4.5E-01	2.4E-08	1.1E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation	=	1.1E-06

Table H.V.1–77
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non–carcinogens	25 Year
EDc	Exposure duration for carcinogens	25 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
arodor–1254	2.5E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E–01	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	6.0E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E–01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1-77 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Incidental Ingestion of Soil

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.9E-06	4.0E-04	9.7E-03
aroclor-1254	2.4E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	5.6E-06	3.0E-04	1.9E-02
beryllium	6.5E-07	5.0E-03	1.3E-04
benzo(a)pyrene	2.0E-08	NA	NA
cadmium	5.8E-07	1.0E-03	5.8E-04
1,2-dichloroethane	NA	NA	NA
magnesium	4.6E-03	9.7E+00	4.8E-04
manganese	7.9E-04	1.4E-01	5.7E-03
mercury	2.0E-07	3.0E-04	6.8E-04
silver	1.8E-06	5.0E-03	3.6E-04
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.4E-10	6.0E-03	1.2E-07
uranium-total	1.1E-05	3.0E-03	3.8E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.0E-02

Compound	TLCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.4E-06	NA	
aroclor-1254	8.6E-09	7.7E+00	6.6E-08
aroclor-1260	NA	7.7E+00	NA
arsenic	2.0E-06	1.8E+00	3.5E-06
beryllium	2.3E-07	4.3E+00	9.9E-07
benzo(a)pyrene	7.0E-09	7.3E+00	5.1E-08
cadmium	2.1E-07	NA	
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.7E-03	NA	
manganese	2.8E-04	NA	
mercury	7.3E-08	NA	
silver	6.4E-07	NA	
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.6E-10	1.1E-02	2.9E-12
uranium-total	4.1E-06	NA	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.6E-06

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Table H.V.1-78
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Commercial/Industrial User
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
EF	Exposure frequency	250 days/year
EDn	Exposure Duration	25 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	1.60E-03	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	3.69E-04	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	2.14E-03	pCi/mg	pCi/mg
$Th_{232+10d}$	1.11E-03	pCi/mg	pCi/mg
$U_{235/236}$	7.06E-05	pCi/mg	pCi/mg
U_{238+2d}	3.85E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.00E+03	7.80E-10	7.80E-07
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	2.31E+02	3.60E-11	8.30E-09
Tc_{99}	1.56E+02	1.30E-12	2.03E-10
Th_{230}	1.34E+03	1.30E-11	1.74E-08
$Th_{232+10d}$	6.94E+02	1.70E-10	1.18E-07
$U_{235/236}$	4.41E+01	1.60E-11	7.06E-10
U_{238+2d}	2.41E+03	2.00E-11	4.81E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 9.73E-07

Table H.V.1-79
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E-06 kg/mg
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non-carcinogens	25 Year
EDc	Exposure duration for carcinogens	25 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	9125 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E-02	3.97E+00	mg/kg		NA	mg/kg
arodor-1254	6.00E-02	2.46E-02	mg/kg		NA	mg/kg
arodor-1260	6.00E-02		mg/kg		NA	mg/kg
arsenic	1.00E-03	5.75E+00	mg/kg		NA	mg/kg
beryllium	1.00E-02	6.62E-01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E-01	2.00E-02	mg/kg		NA	mg/kg
cadmium	1.00E-02	5.96E-01	mg/kg		NA	mg/kg
1,2-dichloroethane	3.00E-01		mg/kg		NA	mg/kg
magnesium	1.00E-02	4.75E+03	mg/kg		NA	mg/kg
manganese	1.00E-02	8.12E+02	mg/kg		NA	mg/kg
mercury	5.00E-02	2.09E-01	mg/kg		NA	mg/kg
silver	1.00E-02	1.84E+00	mg/kg		NA	mg/kg
2,3,7,8-tcdd	3.00E-02		mg/kg		NA	mg/kg
trichloroethene	3.00E-01	7.55E-04	mg/kg		NA	mg/kg
uranium-total	1.00E-02	1.16E+01	mg/kg		NA	mg/kg
	NA		mg/kg			

References

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Table H.V.1-79 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Dermal Contact with Soil

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.23E-06	6.00E-05	3.72E-02
aroclor-1254	8.30E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.24E-07	2.85E-04	1.14E-03
beryllium	3.72E-07	5.00E-03	7.45E-05
benzo(a)pyrene	3.38E-07	NA	NA
cadmium	3.35E-07	5.00E-05	6.71E-03
1,2-dichloroethane	NA	NA	NA
magnesium	2.67E-03	4.85E-01	5.51E-03
manganese	4.57E-04	4.20E-03	1.09E-01
mercury	5.88E-07	4.50E-05	1.31E-02
silver	1.04E-06	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.27E-08	5.88E-03	2.17E-06
uranium-total	6.53E-06	1.50E-04	4.35E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			2.16E-01

Compound	TLCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	7.98E-07	NA	
aroclor-1254	2.97E-08	1.03E+01	3.04E-07
aroclor-1260	NA	1.03E+01	NA
arsenic	1.16E-07	1.84E+00	2.13E-07
beryllium	1.33E-07	4.30E+00	5.72E-07
benzo(a)pyrene	1.21E-07	NA	
cadmium	1.20E-07	NA	
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	9.54E-04	NA	
manganese	1.63E-04	NA	
mercury	2.10E-07	NA	
silver	3.70E-07	NA	
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	4.55E-09	1.12E-02	5.11E-11
uranium-total	2.33E-06	NA	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			1.09E-06

Table H.V.1–80
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Commercial/Industrial User
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.68 (unitless)
ED	Exposure duration	25 Year
ET_i	Fraction of day spent indoors	0.8 (unitless)
ET_o	Fraction of day spent outdoors	0.2 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	1.60E+00	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	3.69E−01	pCi/g	NA	pCi/g
Tc_{99}	2.50E−01	pCi/g	NA	pCi/g
Th_{230}	2.14E+00	pCi/g	NA	pCi/g
$Th_{232+10d}$	1.11E+00	pCi/g	NA	pCi/g
$U_{235/236}$	7.06E−02	pCi/g	NA	pCi/g
U_{238+2d}	3.85E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.6E+01	6.0E−06	9.8E−05
Rn_{222}	NA	1.2E−09	NA
Sr_{90+1d}	3.8E+00	NA	
Tc_{99}	2.6E+00	6.0E−13	1.5E−12
Th_{230}	2.2E+01	5.4E−11	1.2E−09
$Th_{232+10d}$	1.1E+01	8.5E−06	9.6E−05
$U_{235/236}$	7.2E−01	2.4E−07	1.7E−07
U_{238+2d}	3.9E+01	5.1E−08	2.0E−06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 2.0E−04

Table H.V.1–81
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ET	Exposure time	4	4	4	2	hour/day
EF	Exposure frequency	64	104	40	40	days/year
ED	Exposure duration	6	12	38	14	years
BWa	Body weight (adult)	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	days
ATa	Average time for non–carcinogens (adult)	2190	4380	13870	5110	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.0E–09	mg/m^3			mg/m^3
arodor–1254	1.6E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	3.2E–09	mg/m^3			mg/m^3
beryllium	3.5E–10	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E–11	mg/m^3			mg/m^3
cadmium	3.0E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	1.8E–06	mg/m^3			mg/m^3
manganese	4.5E–07	mg/m^3			mg/m^3
mercury	1.5E–10	mg/m^3			mg/m^3
silver	1.1E–09	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E–13	mg/m^3			mg/m^3
uranium–total	1.1E–08	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.V.1-81 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.1E-11	NA	NA
aroclor-1254	1.6E-13	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.3E-11	NA	NA
beryllium	3.6E-12	NA	NA
benzo(a)pyrene	1.2E-13	NA	NA
cadmium	3.2E-12	NA	NA
1,2-dichloroethane	NA	2.9E-03	
magnesium	1.9E-08	NA	NA
manganese	4.7E-09	1.4E-05	3.3E-04
mercury	1.5E-12	8.6E-05	1.8E-08
silver	1.2E-11	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.6E-15	NA	NA
uranium-total	1.1E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.3E-04

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	2.1E-11	NA	NA
aroclor-1254	1.6E-13	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.3E-11	1.5E+01	4.9E-10
beryllium	3.6E-12	8.4E+00	3.0E-11
benzo(a)pyrene	1.2E-13	6.1E+00	7.1E-13
cadmium	3.2E-12	6.3E+00	2.0E-11
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.9E-08	NA	NA
manganese	4.7E-09	NA	NA
mercury	1.5E-12	NA	NA
silver	1.2E-11	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.6E-15	6.0E-03	2.8E-17
uranium-total	1.1E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		5.5E-10

Table H.V.1–82
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via Inhalation of Gases and Particulates

Risk Equation = CA X EF X ED X IR X ET

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ED	Exposure duration	6	12	38	14	years
ET	Exposure time	4	4	4	2	hour/day
EF	Exposure frequency	64	104	40	40	days/year
CA	Concentration of radionuclides in air	csv	csv	csv	csv	

Ra_{226+8d}	8.2E–07	pCi/m^3	pCi/m^3
Rn_{222}	1.1E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	1.9E–07	pCi/m^3	pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3	pCi/m^3
Th_{230}	1.3E–06	pCi/m^3	pCi/m^3
$Th_{232+10d}$	6.0E–07	pCi/m^3	pCi/m^3
$U_{235/236}$	4.7E–08	pCi/m^3	pCi/m^3
U_{238+2d}	3.6E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	9.3E–03	7.0E–09	6.5E–11
Rn_{222}	1.3E+05	7.3E–13	9.4E–08
Sr_{90+1d}	2.1E–03	6.2E–11	1.3E–13
Tc_{99}	1.6E–03	8.3E–12	1.3E–14
Th_{230}	1.4E–02	2.9E–08	4.1E–10
$Th_{232+10d}$	6.8E–03	1.1E–07	7.5E–10
$U_{235/236}$	5.3E–04	2.5E–08	1.3E–11
U_{238+2d}	4.1E–02	2.4E–08	9.7E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 9.6E–08

Table H.V.1-83
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Incidental Ingestion of Soil/Sediment

Risk Equation $= \frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	50	25	25	13	mg/day
EF	Exposure frequency	64	104	40	40	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E-06	1E-06	1E-06	1E-06	kg/mg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non-carcinogens	2190	4380	13870	5110	day
BW	Body weight	15	43	70	70	kg
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
aroclor-1254	2.5E-02	mg/kg			mg/kg
aroclor-1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E-01	mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium	6.0E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E-01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	7.6E-04	mg/kg			mg/kg
uranium-total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1-83 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.1E-07	4.0E-04	1.0E-03
aroclor-1254	2.6E-09	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.0E-07	3.0E-04	2.0E-03
beryllium	6.9E-08	5.0E-03	1.4E-05
benzo(a)pyrene	2.1E-09	NA	NA
cadmium	6.2E-08	1.0E-03	6.2E-05
1,2-dichloroethane	NA	NA	NA
magnesium	4.9E-04	9.7E+00	5.1E-05
manganese	8.4E-05	1.4E-01	6.0E-04
mercury	2.2E-08	3.0E-04	7.2E-05
silver	1.9E-07	5.0E-03	3.8E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.8E-11	6.0E-03	1.3E-08
uranium-total	1.2E-06	3.0E-03	4.0E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.3E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	4.1E-07	NA	NA
aroclor-1254	2.6E-09	7.7E+00	2.0E-08
aroclor-1260	NA	7.7E+00	NA
arsenic	6.0E-07	1.8E+00	1.0E-06
beryllium	6.9E-08	4.3E+00	3.0E-07
benzo(a)pyrene	2.1E-09	7.3E+00	1.5E-08
cadmium	6.2E-08	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	4.9E-04	NA	NA
manganese	8.4E-05	NA	NA
mercury	2.2E-08	NA	NA
silver	1.9E-07	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	7.8E-11	1.1E-02	8.6E-13
uranium-total	1.2E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.4E-06

Table H.V.1-84
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via Incidental Ingestion of Soil/Sediment

Risk Equation = CS X EF X ED X FI X IR

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	50	25	25	13	mg/day
EF	Exposure frequency	64	104	40	40	days/year
ED	Exposure duration	6	12	38	14	year
FI	Fractional Intake	1	1	1	1	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Ra_{226+8d}	1.6E-03	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	3.7E-04	pCi/mg	pCi/mg
Tc_{99}	2.5E-04	pCi/mg	pCi/mg
Th_{230}	2.1E-03	pCi/mg	pCi/mg
$Th_{232+10d}$	1.1E-03	pCi/mg	pCi/mg
$U_{235/236}$	7.1E-05	pCi/mg	pCi/mg
U_{238+2d}	3.9E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.5E-04	7.8E-10	1.2E-13
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	3.5E-05	3.6E-11	1.3E-15
Tc_{99}	2.4E-05	1.3E-12	3.1E-17
Th_{230}	2.0E-04	1.3E-11	2.7E-15
$Th_{232+10d}$	1.1E-04	1.7E-10	1.8E-14
$U_{235/236}$	6.8E-06	1.6E-11	1.1E-16
U_{238+2d}	3.7E-04	2.0E-11	7.4E-15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 1.5E-13

Table H.V.1–85
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact with Soil/Sediment

Risk Equation $= \frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		child	youth	adult	senoir adult
SA	Surface area of exposed skin	2000	4138	5750	5750 cm^2/day
AF	Absorbtion factor	csv	csv	csv	csv (unitless)
EF	Exposure frequency	64	104	40	40 days/year
ED	Exposure duration	6	12	38	14 year
CF	Conversion factor	1E–06	1.000E–06	1E–06	1E–06 kg/mg
BW	Body weight	15	43	70	70 kg
AT	Average time for carcinogens	25550	25550	25550	25550 day
AT	Average time for non–carcinogens	2190	4380	13870	5110 day
ABS	Absorbtion factor	csv	csv	csv	csv (unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv

Chemical Concentrations

Compound	ABS	Concentration	Units	Compound	ABS	Concentration	Units
antimony	1.0E–02	4.0E+00	mg/kg		NA		mg/kg
aroclor–1254	6.0E–02	2.5E–02	mg/kg		NA		mg/kg
aroclor–1260	6.0E–02		mg/kg		NA		mg/kg
arsenic	1.0E–03	5.8E+00	mg/kg		NA		mg/kg
beryllium	1.0E–02	6.6E–01	mg/kg		NA		mg/kg
benzo(a)pyrene	3.0E–01	2.0E–02	mg/kg		NA		mg/kg
cadmium	1.0E–02	6.0E–01	mg/kg		NA		mg/kg
1,2–dichloroethane	3.0E–01		mg/kg		NA		mg/kg
magnesium	1.0E–02	4.8E+03	mg/kg		NA		mg/kg
manganese	1.0E–02	8.1E+02	mg/kg		NA		mg/kg
mercury	5.0E–02	2.1E–01	mg/kg		NA		mg/kg
silver	1.0E–02	1.8E+00	mg/kg		NA		mg/kg
2,3,7,8–tcdd	3.0E–02		mg/kg		NA		mg/kg
trichloroethene	3.0E–01	7.6E–04	mg/kg		NA		mg/kg
uranium–total	1.0E–02	1.2E+01	mg/kg		NA		mg/kg
	NA		mg/kg				

References

Table H.V.1-85 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.3E-07	6.0E-05	8.9E-03
aroclor-1254	2.0E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	7.7E-08	2.9E-04	2.7E-04
beryllium	8.9E-08	5.0E-03	1.8E-05
benzo(a)pyrene	8.0E-08	NA	NA
cadmium	8.0E-08	5.0E-05	1.6E-03
1,2-dichloroethane	NA	NA	NA
magnesium	6.4E-04	4.9E-01	1.3E-03
manganese	1.1E-04	4.2E-03	2.6E-02
mercury	1.4E-07	4.5E-05	3.1E-03
silver	2.5E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.0E-09	5.9E-03	5.2E-07
uranium-total	1.6E-06	1.5E-04	1.0E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.1E-02

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	5.3E-07	NA	NA
aroclor-1254	2.0E-08	1.0E+01	2.0E-07
aroclor-1260	NA	1.0E+01	NA
arsenic	7.7E-08	1.8E+00	1.4E-07
beryllium	8.9E-08	4.3E+00	3.8E-07
benzo(a)pyrene	8.0E-08	NA	NA
cadmium	8.0E-08	NA	NA
1,2-dichloroethane	NA	1.0E-01	NA
magnesium	6.4E-04	NA	NA
manganese	1.1E-04	NA	NA
mercury	1.4E-07	NA	NA
silver	2.5E-07	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
trichloroethene	3.0E-09	1.1E-02	3.4E-11
uranium-total	1.6E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		7.3E-07

000642

Table H.V.1-86
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Ingestion While Wading

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non-carcinogens	2190	4380	13870	5110	days
CS	Concentration of chemicals in surface water	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E-04	mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	1.14E-03	mg/l			mg/l
beryllium	2.38E-05	mg/l			mg/l
benzo(a)pyrene	1.29E-08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	1.92E+01	mg/l			mg/l
manganese	1.42E-01	mg/l			mg/l
mercury	1.01E-03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	5.04E-04	mg/l			mg/l
		mg/l			

References

0006343

Table H.V.1-86 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.07E-09	4.00E-04	5.17E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.27E-08	3.00E-04	7.55E-05
beryllium	4.73E-10	5.00E-03	9.46E-08
benzo(a)pyrene	2.56E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	3.82E-04	9.70E+00	3.93E-05
manganese	2.82E-06	5.00E-03	5.65E-04
mercury	2.01E-08	3.00E-04	6.69E-05
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	1.00E-08	3.00E-03	3.34E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		7.55E-04

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.17E-08

000544

Table H.V.1–87
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact While Wading

Risk Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
SA	Skin surface area		5130			cm^2
DA	chemicals specific dermal absorbed dose	csv	csv	csv	csv	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E–09	mg/cm^2–day			mg/cm^2–day
arodor–1254		mg/cm^2–day			mg/cm^2–day
arodor–1260		mg/cm^2–day			mg/cm^2–day
arsenic	1.14E–08	mg/cm^2–day			mg/cm^2–day
beryllium	2.38E–10	mg/cm^2–day			mg/cm^2–day
benzo(a)pyrene	7.29E–10	mg/cm^2–day			mg/cm^2–day
cadmium		mg/cm^2–day			mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day			mg/cm^2–day
magnesium	1.92E–04	mg/cm^2–day			mg/cm^2–day
manganese	1.42E–06	mg/cm^2–day			mg/cm^2–day
mercury	1.01E–08	mg/cm^2–day			mg/cm^2–day
silver		mg/cm^2–day			mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day			mg/cm^2–day
trichloroethene		mg/cm^2–day			mg/cm^2–day
uranium–total	5.04E–09	mg/cm^2–day			mg/cm^2–day
		mg/cm^2–day			

References

Table H.V.1-87 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.03E-09	6.00E-05	5.05E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.32E-08	2.85E-04	1.17E-04
beryllium	6.93E-10	5.00E-03	1.39E-07
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	5.59E-04	4.85E-01	1.15E-03
manganese	4.14E-06	4.20E-03	9.85E-04
mercury	2.94E-08	4.50E-05	6.54E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	1.47E-08	1.50E-04	9.79E-05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			3.06E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	5.59E-04	NA	NA
manganese	4.14E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	1.47E-08	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			6.42E-08

955000

Table H.V.1-88
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via Incidental Ingestion while Wading

Risk Equation = CS X EF X ED X IRsw

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
Cs	Concentration of radionuclides in surface water	csv	csv	csv	csv	

Ra_{226+8d}	3.5E-01	pCi/l		pCi/l
Rn_{222}		pCi/l		pCi/l
Sr_{90+1d}	2.1E+00	pCi/l		pCi/l
Tc_{99}		pCi/l		pCi/l
Th_{230}	3.1E-03	pCi/l		pCi/l
$Th_{232+10d}$	1.7E-04	pCi/l		pCi/l
$U_{235/236}$	7.5E-03	pCi/l		pCi/l
U_{238+2d}	9.0E-01	pCi/l		pCi/l
		pCi/l		pCi/l
		pCi/l		pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	7.7E+00	7.8E-10	6.0E-09
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	4.5E+01	3.6E-11	1.6E-09
Tc_{99}	NA	1.3E-12	NA
Th_{230}	6.7E-02	1.3E-11	8.7E-13
$Th_{232+10d}$	3.6E-03	1.7E-10	6.2E-13
$U_{235/236}$	1.6E-01	1.6E-11	2.6E-12
U_{238+2d}	2.0E+01	2.0E-11	3.9E-10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 8.0E-09

Table H.V.1-89
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]+[CR \times EF \times ED \times ET_i \times (1-SH_i)]$

		child	youth	adult	senoir adult	
EF	Fraction of year spent exposured	0.18	0.28	0.11	0.11	(unitless)
ED	Exposure duration	6	12	38	14	years
ET_o	Fraction of day spent outdoors	0.17	0.17	0.17	0.08	(unitless)
ET_i	Fraction of day spent indoors	NA	NA	NA	NA	NA
SH_i	Shield factor indoors	0.5	0.5	0.5	0.5	(unitless)
SH_o	Shield factor outdoors					(unitless)
CR	Radionuclide specific concentrations	csv	csv	csv	csv	

Ra_{226+8d}	1.6E+00	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	3.7E-01	pCi/g	NA	pCi/g
Tc_{99}	2.5E-01	pCi/g	NA	pCi/g
Th_{230}	2.1E+00	pCi/g	NA	pCi/g
$Th_{232+10d}$	1.1E+00	pCi/g	NA	pCi/g
$U_{235/236}$	7.1E-02	pCi/g	NA	pCi/g
U_{238+2d}	3.9E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	TLCR (unitless)
Ra_{226+8d}	2.5E+00	6.0E-06	1.5E-05
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	5.9E-01	NA	NA
Tc_{99}	4.0E-01	6.0E-13	2.4E-13
Th_{230}	3.4E+00	5.4E-11	1.8E-10
$Th_{232+10d}$	1.8E+00	8.5E-06	1.5E-05
$U_{235/236}$	1.1E-01	2.4E-07	2.7E-08
U_{238+2d}	6.1E+00	5.1E-08	3.1E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		3.1E-05

Table H.V.1–90
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	26	39	52	26	days/year
ED	Exposure duration	6	12	38	14	years
BWa	Body weight (adult)	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	days
ATa	Average time for non–carcinogens (adult)	2190	4380	13870	5110	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.0E–09	mg/m^3			mg/m^3
arodor–1254	1.6E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	3.2E–09	mg/m^3			mg/m^3
beryllium	3.5E–10	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E–11	mg/m^3			mg/m^3
cadmium	3.0E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	1.8E–06	mg/m^3			mg/m^3
manganese	4.5E–07	mg/m^3			mg/m^3
mercury	1.5E–10	mg/m^3			mg/m^3
silver	1.1E–09	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E–13	mg/m^3			mg/m^3
uranium–total	1.1E–08	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.V.1–90 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	6.2E–12	NA	NA
aroclor–1254	4.8E–14	NA	NA
aroclor–1260	NA	NA	NA
arsenic	9.6E–12	NA	NA
beryllium	1.1E–12	NA	NA
benzo(a)pyrene	3.4E–14	NA	NA
cadmium	9.2E–13	NA	NA
1,2–dichloroethane	NA	2.9E–03	
magnesium	5.6E–09	NA	NA
manganese	1.4E–09	1.4E–05	9.5E–05
mercury	4.5E–13	8.6E–05	5.3E–09
silver	3.4E–12	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.3E–15	NA	NA
uranium–total	3.3E–11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		9.5E–05

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	6.2E–12	NA	NA
aroclor–1254	4.8E–14	NA	NA
aroclor–1260	NA	NA	NA
arsenic	9.6E–12	1.5E+01	1.4E–10
beryllium	1.1E–12	8.4E+00	8.9E–12
benzo(a)pyrene	3.4E–14	6.1E+00	2.1E–13
cadmium	9.2E–13	6.3E+00	5.8E–12
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	5.6E–09	NA	NA
manganese	1.4E–09	NA	NA
mercury	4.5E–13	NA	NA
silver	3.4E–12	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.3E–15	6.0E–03	8.1E–18
uranium–total	3.3E–11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.6E–10

059000

Table H.V.1–91
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via Inhalation of Gases and Particulates

Intake Equation = CA X EF X ED X IR X ET

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ED	Exposure duration	6	12	38	14	years
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	26	39	52	26	days/year
CA	Concentration of radionuclides in air	csv	csv	csv	csv	

Ra_{226+8d}	8.2E–07	pCi/m^3	pCi/m^3
Rn_{222}	1.1E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	1.9E–07	pCi/m^3	pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3	pCi/m^3
Th_{230}	1.3E–06	pCi/m^3	pCi/m^3
$Th_{232+10d}$	6.0E–07	pCi/m^3	pCi/m^3
$U_{235/236}$	4.7E–08	pCi/m^3	pCi/m^3
U_{238+2d}	3.6E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	3.7E–03	7.0E–09	2.6E–11
Rn_{222}	5.1E+04	7.3E–13	3.7E–08
Sr_{90+1d}	8.3E–04	6.2E–11	5.2E–14
Tc_{99}	6.2E–04	8.3E–12	5.1E–15
Th_{230}	5.6E–03	2.9E–08	1.6E–10
$Th_{232+10d}$	2.7E–03	1.1E–07	3.0E–10
$U_{235/236}$	2.1E–04	2.5E–08	5.2E–12
U_{238+2d}	1.6E–02	2.4E–08	3.8E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		3.8E–08

Table H.V.1–92
Summary of Intake Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion of Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	26	39	52	26	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E–06	1E–06	1E–06	1E–06	kg/mg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non–carcinogens	2190	4380	13870	5110	day
BW	Body weight	15	43	70	70	kg
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
aroclor–1254	2.5E–02	mg/kg			mg/kg
aroclor–1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E–01	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	6.0E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E–01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

000652

Table H.V.1-92 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.0E-07	4.0E-04	2.6E-04
aroclor-1254	6.4E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.5E-07	3.0E-04	5.0E-04
beryllium	1.7E-08	5.0E-03	3.4E-06
benzo(a)pyrene	5.2E-10	NA	NA
cadmium	1.5E-08	1.0E-03	1.5E-05
1,2-dichloroethane	NA	NA	NA
magnesium	1.2E-04	9.7E+00	1.3E-05
manganese	2.1E-05	1.4E-01	1.5E-04
mercury	5.4E-09	3.0E-04	1.8E-05
silver	4.8E-08	5.0E-03	9.6E-06
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.0E-11	6.0E-03	3.3E-09
uranium-total	3.0E-07	3.0E-03	1.0E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.1E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	1.0E-07	NA	NA
aroclor-1254	6.4E-10	7.7E+00	4.9E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	1.5E-07	1.8E+00	2.6E-07
beryllium	1.7E-08	4.3E+00	7.4E-08
benzo(a)pyrene	5.2E-10	7.3E+00	3.8E-09
cadmium	1.5E-08	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.2E-04	NA	NA
manganese	2.1E-05	NA	NA
mercury	5.4E-09	NA	NA
silver	4.8E-08	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.0E-11	1.1E-02	2.2E-13
uranium-total	3.0E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		3.4E-07

000653

Table H.V.1–93
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion of Soil/Sediment

Intake Equation = CS X EF X ED X FI X IR

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	26	39	52	26	days/year
ED	Exposure duration	6	12	38	14	year
FI	Fractional Intake	1	1	1	1	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Ra_{226+8d}	1.6E−03	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	3.7E−04	pCi/mg	pCi/mg
Tc_{99}	2.5E−04	pCi/mg	pCi/mg
Th_{230}	2.1E−03	pCi/mg	pCi/mg
$Th_{232+10d}$	1.1E−03	pCi/mg	pCi/mg
$U_{235/236}$	7.1E−05	pCi/mg	pCi/mg
U_{238+2d}	3.9E−03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	5.7E−05	7.8E−10	4.5E−14
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	1.3E−05	3.6E−11	4.8E−16
Tc_{99}	9.0E−06	1.3E−12	1.2E−17
Th_{230}	7.7E−05	1.3E−11	1.0E−15
$Th_{232+10d}$	4.0E−05	1.7E−10	6.8E−15
$U_{235/236}$	2.5E−06	1.6E−11	4.0E−17
U_{238+2d}	1.4E−04	2.0E−11	2.8E−15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		5.6E−14

Table H.V.1–94
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact with Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		child	youth	adult	senoir adult
SA	Surface area of exposed skin	2000	4138	5750	5750 cm^2/day
AF	Absorbtion factor	csv	csv	csv	csv (unitless)
EF	Exposure frequency	26	39	52	26 days/year
ED	Exposure duration	6	12	38	14 year
CF	Conversion factor	1E–06	1.000E–06	1E–06	1E–06 kg/mg
BW	Body weight	15	43	70	70 kg
AT	Average time for carcinogens	25550	25550	25550	25550 day
AT	Average time for non–carcinogens	2190	4380	13870	5110 day
ABS	Absorbtion factor	csv	csv	csv	csv (unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv

Chemical Concentrations

Compound	ABS	Concentration	Units
antimony	1.0E–02	4.0E+00	mg/kg
arodor–1254	6.0E–02	2.5E–02	mg/kg
arodor–1260	6.0E–02		mg/kg
arsenic	1.0E–03	5.8E+00	mg/kg
beryllium	1.0E–02	6.6E–01	mg/kg
benzo(a)pyrene	3.0E–01	2.0E–02	mg/kg
cadmium	1.0E–02	6.0E–01	mg/kg
1,2–dichloroethane	3.0E–01		mg/kg
magnesium	1.0E–02	4.8E+03	mg/kg
manganese	1.0E–02	8.1E+02	mg/kg
mercury	5.0E–02	2.1E–01	mg/kg
silver	1.0E–02	1.8E+00	mg/kg
2,3,7,8–todd	3.0E–02		mg/kg
trichloroethene	3.0E–01	7.6E–04	mg/kg
uranium–total	1.0E–02	1.2E+01	mg/kg
	NA		mg/kg

Compound	ABS	Concentration	Units
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg

References

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Table H.V.1-94 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.0E-07	6.0E-05	6.7E-03
aroclor-1254	1.5E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	5.8E-08	2.9E-04	2.0E-04
beryllium	6.7E-08	5.0E-03	1.3E-05
benzo(a)pyrene	6.1E-08	NA	NA
cadmium	6.0E-08	5.0E-05	1.2E-03
1,2-dichloroethane	NA	NA	NA
magnesium	4.8E-04	4.9E-01	9.9E-04
manganese	8.2E-05	4.2E-03	2.0E-02
mercury	1.1E-07	4.5E-05	2.3E-03
silver	1.9E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.3E-09	5.9E-03	3.9E-07
uranium-total	1.2E-06	1.5E-04	7.8E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.9E-02

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	4.0E-07	NA	NA
aroclor-1254	1.5E-08	1.0E+01	1.5E-07
aroclor-1260	NA	1.0E+01	NA
arsenic	5.8E-08	1.8E+00	1.1E-07
beryllium	6.7E-08	4.3E+00	2.9E-07
benzo(a)pyrene	6.1E-08	NA	NA
cadmium	6.0E-08	NA	NA
1,2-dichloroethane	NA	1.0E-01	NA
magnesium	4.8E-04	NA	NA
manganese	8.2E-05	NA	NA
mercury	1.1E-07	NA	NA
silver	1.9E-07	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
trichloroethene	2.3E-09	1.1E-02	2.6E-11
uranium-total	1.2E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		5.5E-07

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Table H.V.1–95
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Ingestion While Wading

Intake Equation $= \frac{CS \times EF \times ED \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
CS	Concentration of chemicals in surface water	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E–04	mg/l			mg/l
aroclor–1254		mg/l			mg/l
aroclor–1260		mg/l			mg/l
arsenic	1.14E–03	mg/l			mg/l
beryllium	2.38E–05	mg/l			mg/l
benzo(a)pyrene	1.29E–08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2–dichloroethane		mg/l			mg/l
magnesium	1.92E+01	mg/l			mg/l
manganese	1.42E–01	mg/l			mg/l
mercury	1.01E–03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8–tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium–total	5.04E–04	mg/l			mg/l
		mg/l			

References

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Table H.V.1–95 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	2.07E–09	4.00E–04	5.17E–06
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.27E–08	3.00E–04	7.55E–05
beryllium	4.73E–10	5.00E–03	9.46E–08
benzo(a)pyrene	2.56E–13	NA	NA
cadmium	NA	1.00E–03	NA
1,2–dichloroethane	NA	NA	NA
magnesium	3.82E–04	9.70E+00	3.93E–05
manganese	2.82E–06	5.00E–03	5.65E–04
mercury	2.01E–08	3.00E–04	6.69E–05
silver	NA	5.00E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	6.00E–03	NA
uranium–total	1.00E–08	3.00E–03	3.34E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			7.55E–04

	TLCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	TLCR (unitless)
antimony	2.07E–09	NA	NA
aroclor–1254		7.70E+00	NA
aroclor–1260		7.70E+00	NA
arsenic	2.27E–08	1.75E+00	3.97E–08
beryllium	4.73E–10	4.30E+00	2.03E–09
benzo(a)pyrene	2.56E–13	7.30E+00	1.87E–12
cadmium	NA	NA	NA
1,2–dichloroethane		9.10E–02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd		1.50E+05	NA
trichloroethene		1.10E–02	NA
uranium–total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			4.17E–08

000538

Table H.V.1–96
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact While Wading

Intake Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
SA	Skin surface area		5130			cm^2
DA	chemicals specific dermal absorbed dose	csv	csv	csv	csv	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E–09	mg/cm^2–day			mg/cm^2–day
arodor–1254		mg/cm^2–day			mg/cm^2–day
arodor–1260		mg/cm^2–day			mg/cm^2–day
arsenic	1.14E–08	mg/cm^2–day			mg/cm^2–day
beryllium	2.38E–10	mg/cm^2–day			mg/cm^2–day
benzo(a)pyrene	7.29E–10	mg/cm^2–day			mg/cm^2–day
cadmium		mg/cm^2–day			mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day			mg/cm^2–day
magnesium	1.92E–04	mg/cm^2–day			mg/cm^2–day
manganese	1.42E–06	mg/cm^2–day			mg/cm^2–day
mercury	1.01E–08	mg/cm^2–day			mg/cm^2–day
silver		mg/cm^2–day			mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day			mg/cm^2–day
trichloroethene		mg/cm^2–day			mg/cm^2–day
uranium–total	5.04E–09	mg/cm^2–day			mg/cm^2–day
		mg/cm^2–day			

References

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Table H.V.1-96 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.03E-09	6.00E-05	5.05E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.32E-08	2.85E-04	1.17E-04
beryllium	6.93E-10	5.00E-03	1.39E-07
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	5.59E-04	4.85E-01	1.15E-03
manganese	4.14E-06	4.20E-03	9.85E-04
mercury	2.94E-08	4.50E-05	6.54E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	1.47E-08	1.50E-04	9.79E-05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			3.06E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	5.59E-04	NA	NA
manganese	4.14E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	1.47E-08	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			6.42E-08

Table H.V.1-97
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion while Wading

Intake Equation = CS X EF X ED X IRsw

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
Cs	Concentration of radionuclides in surface water	csv	csv	csv	csv	

Ra_{226+8d}	3.5E-01	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	2.1E+00	pCi/l	pCi/l
Tc_{99}		pCi/l	pCi/l
Th_{230}	3.1E-03	pCi/l	pCi/l
$Th_{232+10d}$	1.7E-04	pCi/l	pCi/l
$U_{235/236}$	7.5E-03	pCi/l	pCi/l
U_{238+2d}	9.0E-01	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	7.7E+00	7.8E-10	6.0E-09
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	4.5E+01	3.6E-11	1.6E-09
Tc_{99}	NA	1.3E-12	NA
Th_{230}	6.7E-02	1.3E-11	8.7E-13
$Th_{232+10d}$	3.6E-03	1.7E-10	6.2E-13
$U_{235/236}$	1.6E-01	1.6E-11	2.6E-12
U_{238+2d}	2.0E+01	2.0E-11	3.9E-10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 8.0E-09

Table H.V.1-98
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]+[CR \times EF \times ED \times ET_i \times (1-SH_i)]$

		child	youth	adult	senoir adult	
EF	Fraction of year spent exposured	0.07	0.11	0.14	0.07	(unitless)
ED	Exposure duration	6	12	38	14	years
ET_o	Fraction of day spent outdoors	0.04	0.08	0.08	0.04	(unitless)
ET_i	Fraction of day spent indoors	NA	NA	NA	NA	NA
SH_i	Shield factor indoors	0.5	0.5	0.5	0.5	(unitless)
SH_o	Shield factor outdoors					(unitless)
CR	Radionuclide specific concentrations	csv	csv	csv	csv	

Ra_{226+8d}	1.6E+00	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	3.7E-01	pCi/g	NA	pCi/g
Tc_{99}	2.5E-01	pCi/g	NA	pCi/g
Th_{230}	2.1E+00	pCi/g	NA	pCi/g
$Th_{232+10d}$	1.1E+00	pCi/g	NA	pCi/g
$U_{235/236}$	7.1E-02	pCi/g	NA	pCi/g
U_{238+2d}	3.9E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	TLCR (unitless)
Ra_{226+8d}	9.4E-01	6.0E-06	5.6E-06
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	2.2E-01	NA	NA
Tc_{99}	1.5E-01	6.0E-13	8.8E-14
Th_{230}	1.3E+00	5.4E-11	6.8E-11
$Th_{232+10d}$	6.5E-01	8.5E-06	5.5E-06
$U_{235/236}$	4.1E-02	2.4E-07	9.9E-09
U_{238+2d}	2.3E+00	5.1E-08	1.2E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 1.1E-05

Table H.V.1-99
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		youth	adult	
IR	Inhalation rate of gases	0.83	0.83	m^3/hour
ETa	Exposure time (adult)	2	1	hour/day
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure duration (adult)	12	32	Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.0E-09	mg/m^3			mg/m^3
aroclor-1254	1.6E-11	mg/m^3			mg/m^3
aroclor-1260		mg/m^3			mg/m^3
arsenic	3.2E-09	mg/m^3			mg/m^3
beryllium	3.5E-10	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E-11	mg/m^3			mg/m^3
cadmium	3.0E-10	mg/m^3			mg/m^3
1,2-dichloroethane		mg/m^3			mg/m^3
magnesium	1.8E-06	mg/m^3			mg/m^3
manganese	4.5E-07	mg/m^3			mg/m^3
mercury	1.5E-10	mg/m^3			mg/m^3
silver	1.1E-09	mg/m^3			mg/m^3
2,3,7,8-tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E-13	mg/m^3			mg/m^3
uranium-total	1.1E-08	mg/m^3			mg/m^3
		mg/m^3			

References

000693

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Table H.V.1-99 (**continued**)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.0E-12	NA	NA
aroclor-1254	1.5E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.1E-12	NA	NA
beryllium	3.4E-13	NA	NA
benzo(a)pyrene	1.1E-14	NA	NA
cadmium	2.9E-13	NA	NA
1,2-dichloroethane	NA	2.9E-03	
magnesium	1.8E-09	NA	NA
manganese	4.3E-10	1.4E-05	3.0E-05
mercury	1.4E-13	8.6E-05	1.7E-09
silver	1.1E-12	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.3E-16	NA	NA
uranium-total	1.0E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.0E-05

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	5.2E-12	NA	NA
aroclor-1254	4.1E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.2E-12	1.5E+01	1.2E-10
beryllium	9.0E-13	8.4E+00	7.5E-12
benzo(a)pyrene	2.9E-14	6.1E+00	1.8E-13
cadmium	7.8E-13	6.3E+00	4.9E-12
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	4.8E-09	NA	NA
manganese	1.2E-09	NA	NA
mercury	3.8E-13	NA	NA
silver	2.9E-12	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.1E-15	6.0E-03	6.9E-18
uranium-total	2.8E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.4E-10

0005564

Table H.V.1–100
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via Inhalation of Gases and Particulates

Risk Equation = CA X EF X ED X IR X ET

		youth	adult
IR	Inhalation rate of gases	0.83	0.83 m^3/hour
EFa	Exposure frequency (adult)	110	40 days/year
EDa	Exposure duration	12	32 Year
ETa	Exposure time (adult)	2	1 hour/day
CA	Concentration of radionuclides in air	csv	csv (see table below)

Ra_{226+8d}	8.2E−07	pCi/m^3	pCi/m^3
Rn_{222}	1.1E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	1.9E−07	pCi/m^3	pCi/m^3
Tc_{99}	1.4E−07	pCi/m^3	pCi/m^3
Th_{230}	1.3E−06	pCi/m^3	pCi/m^3
$Th_{232+10d}$	6.0E−07	pCi/m^3	pCi/m^3
$U_{235/236}$	4.7E−08	pCi/m^3	pCi/m^3
U_{238+2d}	3.6E−06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	2.7E−03	7.0E−09	1.9E−11
Rn_{222}	3.7E+04	7.3E−13	2.7E−08
Sr_{90+1d}	6.1E−04	6.2E−11	3.8E−14
Tc_{99}	4.5E−04	8.3E−12	3.7E−15
Th_{230}	4.1E−03	2.9E−08	1.2E−10
$Th_{232+10d}$	2.0E−03	1.1E−07	2.2E−10
$U_{235/236}$	1.5E−04	2.5E−08	3.8E−12
U_{238+2d}	1.2E−02	2.4E−08	2.8E−10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 2.7E−08

Table H.V.1-101
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		youth	adult	
IRa	Ingestion rate of soil (adult)	12.5	12.5	mg/day
CF	Conversion factor	1.00E-06	1.00E-06	kg/mg
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure duration (adult)	12	32	Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in soil	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
arodor-1254	2.5E-02	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E-01	mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium	6.0E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E-01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	7.6E-04	mg/kg			mg/kg
uranium-total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

999900

Table H.V.1-101(continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.5E-07	4.0E-04	3.8E-04
aroclor-1254	9.4E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.2E-07	3.0E-04	7.3E-04
beryllium	2.5E-08	5.0E-03	5.0E-06
benzo(a)pyrene	7.6E-10	NA	NA
cadmium	2.3E-08	1.0E-03	2.3E-05
1,2-dichloroethane	NA	NA	NA
magnesium	1.8E-04	9.7E+00	1.9E-05
manganese	3.1E-05	1.4E-01	2.2E-04
mercury	8.0E-09	3.0E-04	2.7E-05
silver	7.0E-08	5.0E-03	1.4E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.9E-11	6.0E-03	4.8E-09
uranium-total	4.4E-07	3.0E-03	1.5E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			1.6E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	9.5E-08	NA	NA
aroclor-1254	5.9E-10	7.7E+00	4.5E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	1.4E-07	1.8E+00	2.4E-07
beryllium	1.6E-08	4.3E+00	6.8E-08
benzo(a)pyrene	4.8E-10	7.3E+00	3.5E-09
cadmium	1.4E-08	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.1E-04	NA	NA
manganese	1.9E-05	NA	NA
mercury	5.0E-09	NA	NA
silver	4.4E-08	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.8E-11	1.1E-02	2.0E-13
uranium-total	2.8E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			3.2E-07

293000

Table H.V.1–102
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

Risk Equation = CS X EF X ED X FI X IR

		youth	adult	
IRa	Ingestion rate of soil (adult)	12.5	12.5	mg/day
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure Duration	12	32	Year
FI	Fractional Intake	1	1	(unitless)
CS	Concentration of radionuclides in soil	csv	csv	

Ra_{226+8d}	1.6E−03	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	3.7E−04	pCi/mg	pCi/mg
Tc_{99}	2.5E−04	pCi/mg	pCi/mg
Th_{230}	2.1E−03	pCi/mg	pCi/mg
$Th_{232+10d}$	1.1E−03	pCi/mg	pCi/mg
$U_{235/236}$	7.1E−05	pCi/mg	pCi/mg
U_{238+2d}	3.9E−03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	5.2E+01	7.8E−10	4.1E−08
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	1.2E+01	3.6E−11	4.3E−10
Tc_{99}	8.1E+00	1.3E−12	1.1E−11
Th_{230}	7.0E+01	1.3E−11	9.0E−10
$Th_{232+10d}$	3.6E+01	1.7E−10	6.1E−09
$U_{235/236}$	2.3E+00	1.6E−11	3.7E−11
U_{238+2d}	1.3E+02	2.0E−11	2.5E−09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 5.1E−08

Table H.V.1-103
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact with Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		youth	adult	
SA	Surface area of exposed skin (adult)	4200	5750	cm^2/day
AF	Soil to skin adherence factor	1	1	mg/cm^2
ABS	chemicals specific absorbtion factor	csv	csv	
CF	Conversion factor	1.0E−06	1.0E−06	kg/mg
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure duration (adult)	12	32	Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non−carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in soil	csv	csv	

Chemical Concentrations

Compound	ABS	Concentration	Units	Compound	ABS	Concentration	Units
antimony	1.0E−02	4.0E+00	mg/kg		NA		mg/kg
arodor−1254	6.0E−02	2.5E−02	mg/kg		NA		mg/kg
arodor−1260	6.0E−02		mg/kg		NA		mg/kg
arsenic	1.0E−03	5.8E+00	mg/kg		NA		mg/kg
beryllium	1.0E−02	6.6E−01	mg/kg		NA		mg/kg
benzo(a)pyrene	3.0E−01	2.0E−02	mg/kg		NA		mg/kg
cadmium	1.0E−02	6.0E−01	mg/kg		NA		mg/kg
1,2−dichloroethane	3.0E−01		mg/kg		NA		mg/kg
magnesium	1.0E−02	4.8E+03	mg/kg		NA		mg/kg
manganese	1.0E−02	8.1E+02	mg/kg		NA		mg/kg
mercury	5.0E−02	2.1E−01	mg/kg		NA		mg/kg
silver	1.0E−02	1.8E+00	mg/kg		NA		mg/kg
2,3,7,8−tcdd	3.0E−02		mg/kg		NA		mg/kg
trichloroethene	3.0E−01	7.6E−04	mg/kg		NA		mg/kg
uranium−total	1.0E−02	1.2E+01	mg/kg		NA		mg/kg
	NA		mg/kg				

References

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Table H.V.1-103 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.8E-07	6.0E-05	9.6E-03
aroclor-1254	2.2E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.4E-08	2.9E-04	2.9E-04
beryllium	9.6E-08	5.0E-03	1.9E-05
benzo(a)pyrene	8.7E-08	NA	NA
cadmium	8.7E-08	5.0E-05	1.7E-03
1,2-dichloroethane	NA	NA	NA
magnesium	6.9E-04	4.9E-01	1.4E-03
manganese	1.2E-04	4.2E-03	2.8E-02
mercury	1.5E-07	4.5E-05	3.4E-03
silver	2.7E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.3E-09	5.9E-03	5.6E-07
uranium-total	1.7E-06	1.5E-04	1.1E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.6E-02

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	3.6E-07	NA	NA
aroclor-1254	1.4E-08	1.0E+01	1.4E-07
aroclor-1260	NA	1.0E+01	NA
arsenic	5.3E-08	1.8E+00	9.7E-08
beryllium	6.1E-08	4.3E+00	2.6E-07
benzo(a)pyrene	5.5E-08	NA	NA
cadmium	5.5E-08	NA	NA
1,2-dichloroethane	NA	1.0E-01	NA
magnesium	4.4E-04	NA	NA
manganese	7.4E-05	NA	NA
mercury	9.6E-08	NA	NA
silver	1.7E-07	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
trichloroethene	2.1E-09	1.1E-02	2.3E-11
uranium-total	1.1E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		5.0E-07

000620

Table H.V.1-104
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Ingestion While Wading

Risk Equation $= \frac{CS \times EF \times ED \times IR}{BW \times AT}$

		youth	adult	
IRsw	Ingestion rate of surface water	0.035		l/day
EFa	Exposure frequency (adult)	52		days/year
EDa	Exposure duration (adult)	12		Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in surface water	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E-04	mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	1.14E-03	mg/l			mg/l
beryllium	2.38E-05	mg/l			mg/l
benzo(a)pyrene	1.29E-08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	1.92E+01	mg/l			mg/l
manganese	1.42E-01	mg/l			mg/l
mercury	1.01E-03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	5.04E-04	mg/l			mg/l
		mg/l			

References

Table H.V.1-104
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.29E-09	4.00E-04	8.22E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.61E-08	3.00E-04	1.20E-04
beryllium	7.53E-10	5.00E-03	1.51E-07
benzo(a)pyrene	4.08E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	6.07E-04	9.70E+00	6.26E-05
manganese	4.49E-06	5.00E-03	8.98E-04
mercury	3.19E-08	3.00E-04	1.06E-04
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	1.59E-08	3.00E-03	5.31E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.20E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSP $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.17E-08

223000

Table H.V.1–105
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion while Wading

Risk Equation = CS X EF X ED X FI X IRsw

		youth	adult	
IRsw	Ingestion rate of surface water	0.035		l/day
EFa	Exposure frequency (adult)	52		days/year
EDa	Exposure duration (adult)	12		Year
FI	Fractional intake for radionuclides	1		1 (Unitless)
Cs	Concentration of radionuclides in surface water	csv	csv	

Ra_{226+8d}	3.5E−01	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	2.1E+00	pCi/l	pCi/l
Tc_{99}		pCi/l	pCi/l
Th_{230}	3.1E−03	pCi/l	pCi/l
$Th_{232+10d}$	1.7E−04	pCi/l	pCi/l
$U_{235/236}$	7.5E−03	pCi/l	pCi/l
U_{238+2d}	9.0E−01	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	7.7E+00	7.8E−10	6.0E−09
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	4.5E+01	3.6E−11	1.6E−09
Tc_{99}	NA	1.3E−12	NA
Th_{230}	6.7E−02	1.3E−11	8.7E−13
$Th_{232+10d}$	3.6E−03	1.7E−10	6.2E−13
$U_{235/236}$	1.6E−01	1.6E−11	2.6E−12
U_{238+2d}	2.0E+01	2.0E−11	3.9E−10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 8.0E−09

Table H.V.1-106
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact While Wading

Risk Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		youth	adult	
EFa	Exposure frequency (adult)	52		days/year
EDa	Exposure duration (adult)	12		Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
DA	chemicals specific dermal absorbed dose	csv	csv	
SAa	Skin surface area (adult)	5130		cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E-09	mg/cm^2-day			mg/cm^2-day
aroclor-1254		mg/cm^2-day			mg/cm^2-day
aroclor-1260		mg/cm^2-day			mg/cm^2-day
arsenic	1.14E-08	mg/cm^2-day			mg/cm^2-day
beryllium	2.38E-10	mg/cm^2-day			mg/cm^2-day
benzo(a)pyrene	7.29E-10	mg/cm^2-day			mg/cm^2-day
cadmium		mg/cm^2-day			mg/cm^2-day
1,2-dichloroethane		mg/cm^2-day			mg/cm^2-day
magnesium	1.92E-04	mg/cm^2-day			mg/cm^2-day
manganese	1.42E-06	mg/cm^2-day			mg/cm^2-day
mercury	1.01E-08	mg/cm^2-day			mg/cm^2-day
silver		mg/cm^2-day			mg/cm^2-day
2,3,7,8-tcdd		mg/cm^2-day			mg/cm^2-day
trichloroethene		mg/cm^2-day			mg/cm^2-day
uranium-total	5.04E-09	mg/cm^2-day			mg/cm^2-day
		mg/cm^2-day			

References

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Table H.V.1-106 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact While Wading

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.82E-09	6.00E-05	8.03E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	5.28E-08	2.85E-04	1.85E-04
beryllium	1.10E-09	5.00E-03	2.21E-07
benzo(a)pyrene	3.38E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	8.90E-04	4.85E-01	1.84E-03
manganese	6.58E-06	4.20E-03	1.57E-03
mercury	4.68E-08	4.50E-05	1.04E-03
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	2.34E-08	1.50E-04	1.56E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.86E-03

Compound	TLCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	5.59E-04	NA	NA
manganese	4.14E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	1.47E-08	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		6.42E-08

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Table H.V.1-107
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]$

		youth	adult	
EFa	Fraction of year spent exposured (adult)	0.3	0.11	(unitless)
EDa	Exposure duration (adult)	12	32	Year
ET_∞	Fraction of day spent outdoors (adult)	0.08	0.04	(unitless)
SH_o	Shield factor outdoors			(unitless)
CR	Radionuclide specific concentrations	csv	csv	(see table below)

Ra_{226+8d}	1.6E+00	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	3.7E−01	pCi/g	NA	pCi/g
Tc_{99}	2.5E−01	pCi/g	NA	pCi/g
Th_{230}	2.1E+00	pCi/g	NA	pCi/g
$Th_{232+10d}$	1.1E+00	pCi/g	NA	pCi/g
$U_{235/236}$	7.1E−02	pCi/g	NA	pCi/g
U_{238+2d}	3.9E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	TLCR (unitless)
Ra_{226+8d}	6.9E−01	6.0E−06	4.1E−06
Rn_{222}	NA	1.2E−09	NA
Sr_{90+1d}	1.6E−01	NA	NA
Tc_{99}	1.1E−01	6.0E−13	6.4E−14
Th_{230}	9.2E−01	5.4E−11	5.0E−11
$Th_{232+10d}$	4.8E−01	8.5E−06	4.0E−06
$U_{235/236}$	3.0E−02	2.4E−07	7.3E−09
U_{238+2d}	1.7E+00	5.1E−08	8.4E−08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		8.3E−06

Table H.V.1–108
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Meat Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E–10	mg/kg			mg/kg
aroclor–1254		mg/kg			mg/kg
aroclor–1260		mg/kg			mg/kg
arsenic	8.7E–09	mg/kg			mg/kg
beryllium	9.4E–11	mg/kg			mg/kg
benzo(a)pyrene	1.1E–11	mg/kg			mg/kg
cadmium		mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	1.1E–03	mg/kg			mg/kg
manganese	2.3E–07	mg/kg			mg/kg
mercury	1.0E–06	mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene		mg/kg			mg/kg
uranium–total	4.5E–10	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.1-108 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.4E-13	4.0E-04	1.1E-09
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.0E-12	3.0E-04	3.0E-08
beryllium	9.7E-14	5.0E-03	1.9E-11
benzo(a)pyrene	1.2E-14	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	1.1E-06	9.7E+00	1.1E-07
manganese	2.4E-10	1.4E-01	1.7E-09
mercury	1.1E-09	3.0E-04	3.5E-06
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	4.6E-13	3.0E-03	1.5E-10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.7E-06

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	4.4E-13	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	9.0E-12	1.8E+00	1.6E-11
beryllium	9.7E-14	4.3E+00	4.2E-13
benzo(a)pyrene	1.2E-14	7.3E+00	8.4E-14
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.1E-06	NA	NA
manganese	2.4E-10	NA	NA
mercury	1.1E-09	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	4.6E-13	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.6E-11

843000

Table H.V.1–109
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	5.1E–06	pCi/kg	pCi/kg
Rn_{222}	ERR	pCi/kg	pCi/kg
Sr_{90+1d}	1.1E–06	pCi/kg	pCi/kg
Tc_{99}	9.5E–04	pCi/kg	pCi/kg
Th_{230}	1.1E–07	pCi/kg	pCi/kg
$Th_{232+10d}$	2.5E–12	pCi/kg	pCi/kg
$U_{235/236}$	2.5E–06	pCi/kg	pCi/kg
U_{238+2d}	7.7E–06	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	9.5E–03	7.8E–10	7.4E–12
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.1E–03	3.6E–11	7.4E–14
Tc_{99}	1.8E+00	1.3E–12	2.3E–12
Th_{230}	2.0E–04	1.3E–11	2.6E–15
$Th_{232+10d}$	4.7E–09	1.7E–10	8.0E–19
$U_{235/236}$	4.7E–03	1.6E–11	7.4E–14
U_{238+2d}	1.4E–02	2.0E–11	2.9E–13
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 1.0E–11

Table H.V.1–110
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Dairy Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.1E–08	mg/kg			mg/kg
aroclor–1254		mg/kg			mg/kg
aroclor–1260		mg/kg			mg/kg
arsenic	3.1E–07	mg/kg			mg/kg
beryllium	1.0E–10	mg/kg			mg/kg
benzo(a)pyrene	4.2E–09	mg/kg			mg/kg
cadmium		mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	1.0E+00	mg/kg			mg/kg
manganese	2.4E–04	mg/kg			mg/kg
mercury	2.2E–06	mg/kg			mg/kg
silver		mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene		mg/kg			mg/kg
uranium–total	1.6E–06	mg/kg			mg/kg
		mg/kg			

References

000680

Table H.V.1-110 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.1E-10	4.0E-04	5.2E-07
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.3E-09	3.0E-04	4.3E-06
beryllium	4.1E-13	5.0E-03	8.3E-11
benzo(a)pyrene	1.7E-11	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	4.2E-03	9.7E+00	4.3E-04
manganese	9.9E-07	1.4E-01	7.1E-06
mercury	9.1E-09	3.0E-04	3.0E-05
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	6.6E-09	3.0E-03	2.2E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.7E-04

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	2.1E-10	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	1.3E-09	1.8E+00	2.3E-09
beryllium	4.1E-13	4.3E+00	1.8E-12
benzo(a)pyrene	1.7E-11	7.3E+00	1.3E-10
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	4.2E-03	NA	NA
manganese	9.9E-07	NA	NA
mercury	9.1E-09	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	6.6E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		2.4E-09

0006382

Table H.V.1–111
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	1.1E–02	pCi/kg	pCi/kg
Rn_{222}	ERR	pCi/kg	pCi/kg
Sr_{90+1d}	6.7E–03	pCi/kg	pCi/kg
Tc_{99}	1.3E+00	pCi/kg	pCi/kg
Th_{230}	1.1E–04	pCi/kg	pCi/kg
$Th_{232+10d}$	2.5E–09	pCi/kg	pCi/kg
$U_{235/236}$	9.0E–03	pCi/kg	pCi/kg
U_{238+2d}	2.8E–02	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	8.1E+01	7.8E–10	6.3E–08
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	4.9E+01	3.6E–11	1.8E–09
Tc_{99}	9.8E+03	1.3E–12	1.3E–08
Th_{230}	8.0E–01	1.3E–11	1.0E–11
$Th_{232+10d}$	1.9E–05	1.7E–10	3.2E–15
$U_{235/236}$	6.6E+01	1.6E–11	1.1E–09
U_{238+2d}	2.1E+02	2.0E–11	4.1E–09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		8.3E–08

Table H.V.1-112
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User
Via Ingestion of Vegetables and Fruits

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E-05	mg/kg		NA	mg/kg
aroclor-1254		mg/kg		NA	mg/kg
aroclor-1260		mg/kg		NA	mg/kg
arsenic	4.3E-04	mg/kg		NA	mg/kg
beryllium	9.2E-06	mg/kg		NA	mg/kg
benzo(a)pyrene	3.5E-08	mg/kg		NA	mg/kg
cadmium		mg/kg		NA	mg/kg
1,2-dichloroethane		mg/kg		NA	mg/kg
magnesium	2.1E+01	mg/kg		NA	mg/kg
manganese	5.6E-02	mg/kg		NA	mg/kg
mercury	4.0E-04	mg/kg		NA	mg/kg
silver		mg/kg		NA	mg/kg
2,3,7,8-tcdd		mg/kg		NA	mg/kg
trichloroethene		mg/kg		NA	mg/kg
uranium-total	2.2E-04	mg/kg		NA	mg/kg
	NA	mg/kg			

References

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Table H.V.1-112 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.5E-08	4.0E-04	8.7E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.6E-07	3.0E-04	1.2E-03
beryllium	7.6E-09	5.0E-03	1.5E-06
benzo(a)pyrene	2.9E-11	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	1.8E-02	9.7E+00	1.8E-03
manganese	4.7E-05	1.4E-01	3.4E-04
mercury	3.4E-07	3.0E-04	1.1E-03
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	1.8E-07	3.0E-03	6.1E-05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			4.6E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	3.5E-08	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	3.6E-07	1.8E+00	6.2E-07
beryllium	7.6E-09	4.3E+00	3.3E-08
benzo(a)pyrene	2.9E-11	7.3E+00	2.1E-10
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.8E-02	NA	NA
manganese	4.7E-05	NA	NA
mercury	3.4E-07	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	1.8E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation =			6.6E-07

000684

Table H.V.1–113
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	2.0E+00	pCi/kg	NA	pCi/kg
Rn_{222}	ERR	pCi/kg	NA	pCi/kg
Sr_{90+1d}	3.7E−01	pCi/kg	NA	pCi/kg
Tc_{99}	1.1E+01	pCi/kg	NA	pCi/kg
Th_{230}	1.8E+00	pCi/kg	NA	pCi/kg
$Th_{232+10d}$	4.1E−05	pCi/kg	NA	pCi/kg
$U_{235/236}$	1.2E+00	pCi/kg	NA	pCi/kg
U_{238+2d}	3.8E+00	pCi/kg	NA	pCi/kg
	NA	pCi/kg	NA	pCi/kg
	NA	pCi/kg	NA	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	3.0E+03	7.8E−10	2.3E−06
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	5.5E+02	3.6E−11	2.0E−08
Tc_{99}	1.7E+04	1.3E−12	2.2E−08
Th_{230}	2.6E+03	1.3E−11	3.4E−08
$Th_{232+10d}$	6.2E−02	1.7E−10	1.0E−11
$U_{235/236}$	1.8E+03	1.6E−11	2.9E−08
U_{238+2d}	5.7E+03	2.0E−11	1.1E−07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		2.6E−06

Table II.V.1-114
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Residential)
Via Drinking Water Ingestion

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	8.48E-06	mg/l			mg/l
aroclor-1254		mg/l			mg/l
aroclor-1260		mg/l			mg/l
arsenic	8.72E-05	mg/l			mg/l
beryllium	1.87E-06	mg/l			mg/l
benzo(a)pyrene	7.08E-09	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	4.21E+00	mg/l			mg/l
manganese	1.15E-02	mg/l			mg/l
mercury	8.18E-05	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	4.47E-05	mg/l			mg/l
		mg/l			

References

000386

Table H.V.1-114
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Residential)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.32E-07	4.00E-04	5.81E-04
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.39E-06	3.00E-04	7.96E-03
beryllium	5.12E-08	5.00E-03	1.02E-05
benzo(a)pyrene	1.94E-10	NA	NA
cadmium	NA	1.00E-03	
1,2-dichloroethane	NA	NA	NA
magnesium	1.15E-01	9.70E+00	1.19E-02
manganese	3.15E-04	1.40E-01	2.25E-03
mercury	2.24E-06	3.00E-04	7.47E-03
silver	NA	5.00E-03	
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	
uranium-total	1.22E-06	3.00E-03	4.08E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.06E-02

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	2.32E-07	NA	NA
aroclor-1254	NA	7.70E+00	
aroclor-1260	NA	7.70E+00	
arsenic	2.39E-06	1.75E+00	4.18E-06
beryllium	5.12E-08	4.30E+00	2.20E-07
benzo(a)pyrene	1.94E-10	7.30E+00	1.42E-09
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	
magnesium	1.15E-01	NA	NA
manganese	3.15E-04	NA	NA
mercury	2.24E-06	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	
trichloroethene	NA	1.10E-02	
uranium-total	1.22E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		4.40E-06

000687

Table H.V.1–115
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Residential)
Via Ingestion of Drinking Water

Intake Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}	4.1E−01	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	7.4E−02	pCi/l	pCi/l
Tc_{99}	2.2E+00	pCi/l	pCi/l
Th_{230}	3.6E−01	pCi/l	pCi/l
$Th_{232+10d}$	8.4E−06	pCi/l	pCi/l
$U_{235/236}$	2.5E−01	pCi/l	pCi/l
U_{238+2d}	7.7E−01	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	2.0E+04	7.8E−10	1.6E−05
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	3.6E+03	3.6E−11	1.3E−07
Tc_{99}	1.1E+05	1.3E−12	1.4E−07
Th_{230}	1.8E+04	1.3E−11	2.3E−07
$Th_{232+10d}$	4.1E−01	1.7E−10	7.0E−11
$U_{235/236}$	1.2E+04	1.6E−11	2.0E−07
U_{238+2d}	3.8E+04	2.0E−11	7.6E−07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

TLCR Summation = 1.7E−05

Table H.V.1–116
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Residential)
Via Dermal Contact while Bathing

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2–day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	2.12E–11	mg/cm^2–day			mg/cm^2–day
aroclor–1254		mg/cm^2–day			mg/cm^2–day
aroclor–1260		mg/cm^2–day			mg/cm^2–day
arsenic	2.18E–10	mg/cm^2–day			mg/cm^2–day
beryllium	4.68E–12	mg/cm^2–day			mg/cm^2–day
benzo(a)pyrene	2.00E–10	mg/cm^2–day			mg/cm^2–day
cadmium		mg/cm^2–day			mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day			mg/cm^2–day
magnesium	1.05E–05	mg/cm^2–day			mg/cm^2–day
manganese	2.88E–08	mg/cm^2–day			mg/cm^2–day
mercury	2.05E–10	mg/cm^2–day			mg/cm^2–day
silver		mg/cm^2–day			mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day			mg/cm^2–day
trichloroethene		mg/cm^2–day			mg/cm^2–day
uranium–total	1.12E–10	mg/cm^2–day			mg/cm^2–day
		mg/cm^2–day			

References

Table H.V.1-116 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	6.68E-09	6.00E-05	1.11E-04
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.87E-08	2.85E-04	2.41E-04
beryllium	1.47E-09	5.00E-03	2.95E-07
benzo(a)pyrene	6.30E-08	NA	NA
cadmium	NA	5.00E-05	
1,2-dichloroethane	NA	NA	NA
magnesium	3.32E-03	4.85E-01	6.84E-03
manganese	9.06E-06	4.20E-03	2.16E-03
mercury	6.44E-08	4.50E-05	1.43E-03
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	
uranium-total	3.52E-08	1.50E-04	2.35E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.10E-02

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	6.68E-09	NA	NA
aroclor-1254	NA	1.03E+01	
aroclor-1260	NA	1.03E+01	
arsenic	6.87E-08	1.84E+00	1.27E-07
beryllium	1.47E-09	4.30E+00	6.33E-09
benzo(a)pyrene	6.30E-08	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	3.32E-03	NA	NA
manganese	9.06E-06	NA	NA
mercury	6.44E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	NA	1.12E-02	
uranium-total	3.52E-08	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.33E-07

063090

Table H.V.1-117
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Ingestion of Fish

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fish	0.054 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	122 days/year
EDn	Exposure duration for non-carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	10950 days
CS	Concentration of chemicals in meat	csv

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	8.5E-06	mg/kg		NA	mg/kg
aroclor-1254	NA	mg/kg		NA	mg/kg
aroclor-1260	NA	mg/kg		NA	mg/kg
arsenic	3.8E-03	mg/kg		NA	mg/kg
beryllium	3.6E-05	mg/kg		NA	mg/kg
benzo(a)pyrene	1.8E-04	mg/kg		NA	mg/kg
cadmium	NA	mg/kg		NA	mg/kg
1,2-dichloroethane	NA	mg/kg		NA	mg/kg
magnesium		mg/kg		NA	mg/kg
manganese		mg/kg		NA	mg/kg
mercury	4.5E-01	mg/kg		NA	mg/kg
silver	NA	mg/kg		NA	mg/kg
2,3,7,8-tcdd	NA	mg/kg		NA	mg/kg
trichloroethene	NA	mg/kg		NA	mg/kg
uranium-total	8.9E-08	mg/kg		NA	mg/kg
	NA	mg/kg			

References

753000

Table H.V.1-117 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Ingestion of Fish

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.2E-09	4.0E-04	5.5E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.9E-07	3.0E-04	3.3E-03
beryllium	9.2E-09	5.0E-03	1.8E-06
benzo(a)pyrene	4.6E-08	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.7E+00	NA
manganese	NA	1.4E-01	NA
mercury	1.2E-04	3.0E-04	3.9E-01
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	2.3E-11	3.0E-03	7.7E-09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.9E-01

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	TLCR (unitless)
antimony	9.4E-10	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	4.2E-07	1.8E+00	7.4E-07
beryllium	3.9E-09	4.3E+00	1.7E-08
benzo(a)pyrene	2.0E-08	7.3E+00	1.5E-07
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	5.0E-05	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	9.9E-12	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		9.0E-07

0006392

Table H.V.1-118
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Recreational)
Via Ingestion of Fish

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.054 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	122 days/year
EDn	Exposure duration	30 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	2.1E-02	pCi/kg	NA	pCi/kg
Rn_{222}	NA	pCi/kg	NA	pCi/kg
Sr_{90+1d}	2.2E-03	pCi/kg	NA	pCi/kg
Tc_{99}	3.3E-02	pCi/kg	NA	pCi/kg
Th_{230}	1.1E-02	pCi/kg	NA	pCi/kg
$Th_{232+10d}$	2.5E-07	pCi/kg	NA	pCi/kg
$U_{235/236}$	5.0E-04	pCi/kg	NA	pCi/kg
U_{238+2d}	1.5E-03	pCi/kg	NA	pCi/kg
	NA	pCi/kg	NA	pCi/kg
	NA	pCi/kg	NA	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	1.0E-03	7.8E-10	7.9E-13
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	2.2E-04	3.6E-11	7.9E-15
Tc_{99}	1.9E-01	1.3E-12	2.4E-13
Th_{230}	2.1E-05	1.3E-11	2.8E-16
$Th_{232+10d}$	5.0E-10	1.7E-10	8.5E-20
$U_{235/236}$	5.0E-04	1.6E-11	7.9E-15
U_{238+2d}	1.5E-03	2.0E-11	3.1E-14
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		1.1E-12

Table II.V.1–119
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Incidental Ingestion While Wading

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non–carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	10950 days
ATn	Average time for non–carcinogens (EDn x 365)	10950 days
CS	Concentration of chemicals in surface water	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	8.48E–06	$mg/cm^2–d$			$mg/cm^2–d$
aroclor–1254		$mg/cm^2–d$			$mg/cm^2–d$
aroclor–1260		$mg/cm^2–d$			$mg/cm^2–d$
arsenic	8.72E–05	$mg/cm^2–d$			$mg/cm^2–d$
beryllium	1.87E–06	$mg/cm^2–d$			$mg/cm^2–d$
benzo(a)pyrene	7.08E–09	$mg/cm^2–d$			$mg/cm^2–d$
cadmium		$mg/cm^2–d$			$mg/cm^2–d$
1,2–dichloroethane		$mg/cm^2–d$			$mg/cm^2–d$
magnesium	4.21E+00	$mg/cm^2–d$			$mg/cm^2–d$
manganese	1.15E–02	$mg/cm^2–d$			$mg/cm^2–d$
mercury	8.18E–05	$mg/cm^2–d$			$mg/cm^2–d$
silver		$mg/cm^2–d$			$mg/cm^2–d$
2,3,7,8–tcdd		$mg/cm^2–d$			$mg/cm^2–d$
trichloroethene		$mg/cm^2–d$			$mg/cm^2–d$
uranium–total	4.47E–05	$mg/cm^2–d$			$mg/cm^2–d$
		$mg/cm^2–d$			

References

065994

Table H.V.1-119 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Incidental Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.13E-11	4.00E-04	2.03E-07
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.36E-10	3.00E-04	2.79E-06
beryllium	1.79E-11	5.00E-03	3.59E-09
benzo(a)pyrene	6.79E-14	NA	ERR
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	4.04E-05	9.70E+00	4.16E-06
manganese	1.10E-07	5.00E-03	2.21E-05
mercury	7.84E-10	3.00E-04	2.61E-06
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	4.29E-10	3.00E-03	1.43E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		ERR

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	TLCR (unitless)
antimony	8.13E-11	NA	
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	8.36E-10	1.75E+00	1.46E-09
beryllium	1.79E-11	4.30E+00	7.71E-11
benzo(a)pyrene	6.79E-14	7.30E+00	4.96E-13
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	4.04E-05	NA	
manganese	1.10E-07	NA	
mercury	7.84E-10	NA	
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	4.29E-10	NA	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.54E-09

0006395

Table H.V.1-120
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Recreational)
Via Incidental Ingestion while Wading

Intake Equation = Cs X EF X ED X FI X IR

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non-carcinogens	30 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cs	Concentration of radionuclides in surface water	

Ra_{226+8d}	4.10E-01	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	7.43E-02	pCi/l	pCi/l
Tc_{99}	2.23E+00	pCi/l	pCi/l
Th_{230}	3.61E-01	pCi/l	pCi/l
$Th_{232+10d}$	8.44E-06	pCi/l	pCi/l
$U_{235/236}$	2.51E-01	pCi/l	pCi/l
U_{238+2d}	7.75E-01	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	TLCR (unitless)
Ra_{226+8d}	3.01E+00	7.80E-10	2.35E-09
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	5.46E-01	3.60E-11	1.97E-11
Tc_{99}	1.64E+01	1.30E-12	2.13E-11
Th_{230}	2.66E+00	1.30E-11	3.45E-11
$Th_{232+10d}$	6.20E-05	1.70E-10	1.05E-14
$U_{235/236}$	1.84E+00	1.60E-11	2.95E-11
U_{238+2d}	5.70E+00	2.00E-11	1.14E-10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
TLCR Summation	=		2.57E-09

Table H.V.1-121
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Dermal Contact while Wading

Intake Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2-day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non-carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	2.12E-11	mg/cm^2-day			mg/cm^2-day
aroclor-1254		mg/cm^2-day			mg/cm^2-day
aroclor-1260		mg/cm^2-day			mg/cm^2-day
arsenic	2.18E-10	mg/cm^2-day			mg/cm^2-day
beryllium	4.68E-12	mg/cm^2-day			mg/cm^2-day
benzo(a)pyrene	2.00E-10	mg/cm^2-day			mg/cm^2-day
cadmium		mg/cm^2-day			mg/cm^2-day
1,2-dichloroethane		mg/cm^2-day			mg/cm^2-day
magnesium	1.05E-05	mg/cm^2-day			mg/cm^2-day
manganese	2.88E-08	mg/cm^2-day			mg/cm^2-day
mercury	2.05E-10	mg/cm^2-day			mg/cm^2-day
silver		mg/cm^2-day			mg/cm^2-day
2,3,7,8-tcdd		mg/cm^2-day			mg/cm^2-day
trichloroethene		mg/cm^2-day			mg/cm^2-day
uranium-total	1.12E-10	mg/cm^2-day			mg/cm^2-day
		mg/cm^2-day			

References

259000

Table H.V.1-121 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.25E-09	6.00E-05	2.08E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.28E-08	2.85E-04	4.50E-05
beryllium	2.75E-10	5.00E-03	5.50E-08
benzo(a)pyrene	5.88E-09	NA	NA
cadmium	NA	5.00E-05	
1,2-dichloroethane	NA	NA	NA
magnesium	6.19E-04	4.85E-01	1.28E-03
manganese	1.69E-06	4.20E-03	4.03E-04
mercury	1.20E-08	4.50E-05	2.67E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	
uranium-total	6.57E-09	1.50E-04	4.38E-05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.06E-03

	TLCR Calculation		
Compound	CDI (mg/kg-day)	CSF (mg/kg-day)	TLCR (unitless)
antimony	5.34E-10	NA	NA
aroclor-1254	NA	1.03E+01	
aroclor-1260	NA	1.03E+01	
arsenic	5.49E-09	1.84E+00	1.01E-08
beryllium	1.18E-10	4.30E+00	5.07E-10
benzo(a)pyrene	2.52E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	2.65E-04	NA	NA
manganese	7.25E-07	NA	NA
mercury	5.15E-09	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	NA	1.12E-02	
uranium-total	2.82E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	TLCR Summation =		1.06E-08

ATTACHMENT H.V
BACKGROUND CONTRIBUTIONS TO RISK
H.V-2 RISK CHARACTERIZATION USING OPTION B

TABLE H.V.2-1

SUMMARY OF OPTION B HEALTH EFFECTS: FOR ALL RECEPTORS

Target Receptor	Risk	HI
Undeveloped	3.0E-06	5.1E-02
Off-Property Resident Farm		
Adult	3.2E-04	3.5E+00
Child	1.2E-04	1.7E+01

Reference Receptor	Risk	HI
On-Property Resident Farm		
Adult	5.9E-04	7.1E+00
Child	1.7E-04	3.6E+01
Commercial/Industrial User	3.4E-05	2.6E-01
Developed Park User	6.5E-06	6.0E-02
Wildlife Reserve User	2.6E-06	4.4E-02
Expanded Trespasser	2.1E-06	6.4E-02
Meat and Milk Consumer	3.9E-05	1.3E+00
Great Miami River User	6.5E-06	4.4E-01

Table H.V.2–2
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	years
BWa	Body weight (adult)	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	days
ATa	Average time for non–carcinogens (adult)	2190	4380	13870	5110	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.0E–09	mg/m^3			mg/m^3
arodor–1254	1.6E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	3.2E–09	mg/m^3			mg/m^3
beryllium	3.5E–10	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E–11	mg/m^3			mg/m^3
cadmium	3.0E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	1.8E–06	mg/m^3			mg/m^3
manganese	4.5E–07	mg/m^3			mg/m^3
mercury	1.5E–10	mg/m^3			mg/m^3
silver	1.1E–09	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E–13	mg/m^3			mg/m^3
uranium–total	1.1E–08	mg/m^3			mg/m^3
		mg/m^3			

References

000704

Table H.V.2-2 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.0E-12	NA	NA
aroclor-1254	6.3E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.3E-11	NA	NA
beryllium	1.4E-12	NA	NA
benzo(a)pyrene	4.4E-14	NA	NA
cadmium	1.2E-12	NA	NA
1,2-dichloroethane	NA	2.9E-03	
magnesium	7.3E-09	NA	NA
manganese	1.8E-09	1.4E-05	1.2E-04
mercury	5.9E-13	8.6E-05	6.9E-09
silver	4.5E-12	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.8E-15	NA	NA
uranium-total	4.3E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.2E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	8.0E-12	NA	NA
aroclor-1254	6.3E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.3E-11	1.5E+01	1.9E-10
beryllium	1.4E-12	8.4E+00	1.2E-11
benzo(a)pyrene	4.4E-14	6.1E+00	2.7E-13
cadmium	1.2E-12	6.3E+00	7.6E-12
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	7.3E-09	NA	NA
manganese	1.8E-09	NA	NA
mercury	5.9E-13	NA	NA
silver	4.5E-12	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.8E-15	6.0E-03	1.1E-17
uranium-total	4.3E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.1E-10

000202

Table H.V.2–3
Summary of Risk Quantitation (radionuclides)
Target Recptor: Undeveloped Park User
Via Inhalation of Gases and Particulates

Risk Equation = CA X EF X ED X IR X ET

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ED	Exposure duration	6	12	38	14	years
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	40	104	40	26	days/year
CA	Concentration of radionuclides in air	csv	csv	csv	csv	

Ra_{226+8d}	1.4E–07	pCi/m^3	pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3	pCi/m^3
Sr_{90+1d}	4.8E–08	pCi/m^3	pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3	pCi/m^3
Th_{230}	4.2E–07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	4.0E–09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.0E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	7.2E–04	7.0E–09	5.1E–12
Rn_{222}	9.4E+03	7.3E–13	6.8E–09
Sr_{90+1d}	2.4E–04	6.2E–11	1.5E–14
Tc_{99}	7.0E–04	8.3E–12	5.8E–15
Th_{230}	2.1E–03	2.9E–08	6.2E–11
$Th_{232+10d}$	2.0E–05	1.1E–07	2.2E–12
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	1.5E–02	2.4E–08	3.6E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		7.3E–09

Table H.V.2-4
Summary of Risk Quantitation (chemicals)
Target Recptor: Undeveloped Park User
Via Incidental Ingestion of Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E-06	1E-06	1E-06	1E-06	kg/mg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non-carcinogens	2190	4380	13870	5110	day
BW	Body weight	15	43	70	70	kg
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units
antimony	4.0E+00	mg/kg
arodor-1254	2.5E-02	mg/kg
arodor-1260		mg/kg
arsenic	5.8E+00	mg/kg
beryllium	6.6E-01	mg/kg
benzo(a)pyrene	2.0E-02	mg/kg
cadmium	6.0E-01	mg/kg
1,2-dichloroethane		mg/kg
magnesium	4.8E+03	mg/kg
manganese	8.1E+02	mg/kg
mercury	2.1E-01	mg/kg
silver	1.8E+00	mg/kg
2,3,7,8-tcdd		mg/kg
trichloroethene	7.6E-04	mg/kg
uranium-total	1.2E+01	mg/kg
		mg/kg

Compound	Concentration	Units
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg

References

000704

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Table H.V.2-4 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.4E-07	4.0E-04	3.4E-04
aroclor-1254	8.5E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.0E-07	3.0E-04	6.6E-04
beryllium	2.3E-08	5.0E-03	4.6E-06
benzo(a)pyrene	6.9E-10	NA	NA
cadmium	2.1E-08	1.0E-03	2.1E-05
1,2-dichloroethane	NA	NA	NA
magnesium	1.6E-04	9.7E+00	1.7E-05
manganese	2.8E-05	1.4E-01	2.0E-04
mercury	7.2E-09	3.0E-04	2.4E-05
silver	6.4E-08	5.0E-03	1.3E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.6E-11	6.0E-03	4.3E-09
uranium-total	4.0E-07	3.0E-03	1.3E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.4E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.4E-07	NA	NA
aroclor-1254	8.5E-10	7.7E+00	6.5E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	2.0E-07	1.8E+00	3.5E-07
beryllium	2.3E-08	4.3E+00	9.8E-08
benzo(a)pyrene	6.9E-10	7.3E+00	5.0E-09
cadmium	2.1E-08	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.6E-04	NA	NA
manganese	2.8E-05	NA	NA
mercury	7.2E-09	NA	NA
silver	6.4E-08	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.6E-11	1.1E-02	2.9E-13
uranium-total	4.0E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.6E-07

002000

Table H.V.2-5
Summary of Risk Quantitation (radionuclides)
Target Recptor: Undeveloped Park User
Via Incidental Ingestion of Soil/Sediment

Risk Equation = CS X EF X ED X FI X IR

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	year
FI	Fractional Intake	1	1	1	1	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Ra_{226+8d}	3.8E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.2E-04	pCi/mg	pCi/mg
Tc_{99}	2.5E-04	pCi/mg	pCi/mg
Th_{230}	6.5E-04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.2E-05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.8E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E-05	7.8E-10	1.2E-14
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	4.9E-06	3.6E-11	1.8E-16
Tc_{99}	1.0E-05	1.3E-12	1.3E-17
Th_{230}	2.6E-05	1.3E-11	3.4E-16
$Th_{232+10d}$	1.3E-06	1.7E-10	2.2E-16
$U_{235/236}$	NA	1.6E-11	NA
U_{238+2d}	1.1E-04	2.0E-11	2.3E-15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.5E-14

Table H.V.2-6
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact with Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
SA	Surface area of exposed skin	2000	4138	5750	5750	cm^2/day
AF	Absorbtion factor	csv	csv	csv	csv	(unitless)
EF	Exposure frequency	40	104	40	26	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E-06	1.000E-06	1E-06	1E-06	kg/mg
BW	Body weight	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non-carcinogens	2190	4380	13870	5110	day
ABS	Absorbtion factor	csv	csv	csv	csv	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	ABS	Concentration	Units	Compound	ABS	Concentration	Units
antimony	1.0E-02	4.0E+00	mg/kg		NA		mg/kg
arodor-1254	6.0E-02	2.5E-02	mg/kg		NA		mg/kg
arodor-1260	6.0E-02		mg/kg		NA		mg/kg
arsenic	1.0E-03	5.8E+00	mg/kg		NA		mg/kg
beryllium	1.0E-02	6.6E-01	mg/kg		NA		mg/kg
benzo(a)pyrene	3.0E-01	2.0E-02	mg/kg		NA		mg/kg
cadmium	1.0E-02	6.0E-01	mg/kg		NA		mg/kg
1,2-dichloroethane	3.0E-01		mg/kg		NA		mg/kg
magnesium	1.0E-02	4.8E+03	mg/kg		NA		mg/kg
manganese	1.0E-02	8.1E+02	mg/kg		NA		mg/kg
mercury	5.0E-02	2.1E-01	mg/kg		NA		mg/kg
silver	1.0E-02	1.8E+00	mg/kg		NA		mg/kg
2,3,7,8-todd	3.0E-02		mg/kg		NA		mg/kg
trichloroethene	3.0E-01	7.6E-04	mg/kg		NA		mg/kg
uranium-total	1.0E-02	1.2E+01	mg/kg		NA		mg/kg
	NA		mg/kg				

References

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Table H.V.2-6 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.8E-07	6.0E-05	7.9E-03
aroclor-1254	1.8E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.9E-08	2.9E-04	2.4E-04
beryllium	8.0E-08	5.0E-03	1.6E-05
benzo(a)pyrene	7.2E-08	NA	NA
cadmium	7.2E-08	5.0E-05	1.4E-03
1,2-dichloroethane	NA	NA	NA
magnesium	5.7E-04	4.9E-01	1.2E-03
manganese	9.8E-05	4.2E-03	2.3E-02
mercury	1.3E-07	4.5E-05	2.8E-03
silver	2.2E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.7E-09	5.9E-03	4.6E-07
uranium-total	1.4E-06	1.5E-04	9.3E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.6E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	4.8E-07	NA	NA
aroclor-1254	1.8E-08	1.0E+01	1.8E-07
aroclor-1260	NA	1.0E+01	NA
arsenic	6.9E-08	1.8E+00	1.3E-07
beryllium	8.0E-08	4.3E+00	3.4E-07
benzo(a)pyrene	7.2E-08	NA	NA
cadmium	7.2E-08	NA	NA
1,2-dichloroethane	NA	1.0E-01	NA
magnesium	5.7E-04	NA	NA
manganese	9.8E-05	NA	NA
mercury	1.3E-07	NA	NA
silver	2.2E-07	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
trichloroethene	2.7E-09	1.1E-02	3.1E-11
uranium-total	1.4E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.5E-07

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Table H.V.2–7
Summary of Risk Quantitation (chemicals)
Target Recptor: Undeveloped Park User
Via Ingestion While Wading

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
CS	Concentration of chemicals in surface water	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E–04	mg/l			mg/l
arodor–1254		mg/l			mg/l
arodor–1260		mg/l			mg/l
arsenic	1.14E–03	mg/l			mg/l
beryllium	2.38E–05	mg/l			mg/l
benzo(a)pyrene	1.29E–08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2–dichloroethane		mg/l			mg/l
magnesium	1.92E+01	mg/l			mg/l
manganese	1.42E–01	mg/l			mg/l
mercury	1.01E–03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8–tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium–total	5.04E–04	mg/l			mg/l
		mg/l			

References

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Table H.V.2-7 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.07E-09	4.00E-04	5.17E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.27E-08	3.00E-04	7.55E-05
beryllium	4.73E-10	5.00E-03	9.46E-08
benzo(a)pyrene	2.56E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	3.82E-04	9.70E+00	3.93E-05
manganese	2.82E-06	5.00E-03	5.65E-04
mercury	2.01E-08	3.00E-04	6.69E-05
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	1.00E-08	3.00E-03	3.34E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		7.55E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.17E-08

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Table H.V.2–8
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact While Wading

Risk Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
SA	Skin surface area		5130			cm^2
DA	chemicals specific dermal absorbed dose	csv	csv	csv	csv	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E–09	mg/cm^2–day			mg/cm^2–day
arodor–1254		mg/cm^2–day			mg/cm^2–day
arodor–1260		mg/cm^2–day			mg/cm^2–day
arsenic	1.14E–08	mg/cm^2–day			mg/cm^2–day
beryllium	2.38E–10	mg/cm^2–day			mg/cm^2–day
benzo(a)pyrene	7.29E–10	mg/cm^2–day			mg/cm^2–day
cadmium		mg/cm^2–day			mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day			mg/cm^2–day
magnesium	1.92E–04	mg/cm^2–day			mg/cm^2–day
manganese	1.42E–06	mg/cm^2–day			mg/cm^2–day
mercury	1.01E–08	mg/cm^2–day			mg/cm^2–day
silver		mg/cm^2–day			mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day			mg/cm^2–day
trichloroethene		mg/cm^2–day			mg/cm^2–day
uranium–total	5.04E–09	mg/cm^2–day			mg/cm^2–day
		mg/cm^2–day			

References

000242

Table H.V.2-8 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Undeveloped Park User
Via Dermal Contact While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.03E-09	6.00E-05	5.05E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.32E-08	2.85E-04	1.17E-04
beryllium	6.93E-10	5.00E-03	1.39E-07
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	5.59E-04	4.85E-01	1.15E-03
manganese	4.14E-06	4.20E-03	9.85E-04
mercury	2.94E-08	4.50E-05	6.54E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	1.47E-08	1.50E-04	9.79E-05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.06E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	5.59E-04	NA	NA
manganese	4.14E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	1.47E-08	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.42E-08

000742

Table H.V.2-9
Summary of Risk Quantitation (radionuclides)
Target Recptor: Undeveloped Park User
Via Incidental Ingestion while Wading

Risk Equation = CS X EF X ED X IRsw

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
Cs	Concentration of radionuclides in surface water	csv	csv	csv	csv	

Ra_{226+8d}	1.5E-03	pCi/l		pCi/l
Rn_{222}		pCi/l		pCi/l
Sr_{90+1d}	1.1E+00	pCi/l		pCi/l
Tc_{99}		pCi/l		pCi/l
Th_{230}	3.1E-03	pCi/l		pCi/l
$Th_{232+10d}$	1.7E-04	pCi/l		pCi/l
$U_{235/236}$	7.5E-03	pCi/l		pCi/l
U_{238+2d}	1.7E-01	pCi/l		pCi/l
		pCi/l		pCi/l
		pCi/l		pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.2E-02	7.8E-10	2.5E-11
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	2.4E+01	3.6E-11	8.6E-10
Tc_{99}	NA	1.3E-12	NA
Th_{230}	6.7E-02	1.3E-11	8.7E-13
$Th_{232+10d}$	3.6E-03	1.7E-10	6.2E-13
$U_{235/236}$	1.6E-01	1.6E-11	2.6E-12
U_{238+2d}	3.7E+00	2.0E-11	7.3E-11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		9.6E-10

Table H.V.2-10
Summary of Risk Quantitation (radionuclides)
Target Recptor: Undeveloped Park User
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]+[CR \times EF \times ED \times ET_i \times (1-SH_i)]$

		child	youth	adult	senoir adult	
EF	Fraction of year spent exposured	0.11	0.28	0.11	0.07	(unitless)
ED	Exposure duration	6	12	38	14	years
ET_o	Fraction of day spent outdoors	0.04	0.08	0.08	0.04	(unitless)
ETi	Fraction of day spent indoors	NA	NA	NA	NA	NA
SH_i	Shield factor indoors	0.5	0.5	0.5	0.5	(unitless)
SH_o	Shield factor outdoors					(unitless)
CR	Radionuclide specific concentrations	csv	csv	csv	csv	

Ra_{226+8d}	3.8E-01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.2E-01	pCi/g	NA	pCi/g
Tc_{99}	2.5E-01	pCi/g	NA	pCi/g
Th_{230}	6.5E-01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.2E-02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.8E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.6E-01	6.0E-06	1.5E-06
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	8.0E-02	NA	NA
Tc_{99}	1.7E-01	6.0E-13	1.0E-13
Th_{230}	4.3E-01	5.4E-11	2.3E-11
$Th_{232+10d}$	2.1E-02	8.5E-06	1.8E-07
$U_{235/236}$	NA	2.4E-07	NA
U_{238+2d}	1.9E+00	5.1E-08	9.4E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.8E-06

Table H.V.2-11
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
antimony	1.2E-09	mg/m^3
arodor-1254	1.2E-11	mg/m^3
arodor-1260		mg/m^3
arsenic	2.2E-09	mg/m^3
beryllium	2.5E-10	mg/m^3
benzo(a)pyrene	9.3E-12	mg/m^3
cadmium	2.4E-10	mg/m^3
1,2-dichloroethane		mg/m^3
magnesium	1.3E-06	mg/m^3
manganese	3.4E-07	mg/m^3
mercury	7.7E-11	mg/m^3
silver	6.0E-10	mg/m^3
2,3,7,8-tcdd		mg/m^3
trichloroethene	6.4E-13	mg/m^3
uranium-total	6.3E-09	mg/m^3
		mg/m^3

Compound	Concentration	Units
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3

References

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Table H.V.2-11 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.2E-10	NA	NA
aroclor-1254	3.2E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.1E-10	NA	NA
beryllium	6.9E-11	NA	NA
benzo(a)pyrene	2.6E-12	NA	NA
cadmium	6.7E-11	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	3.5E-07	NA	NA
manganese	9.3E-08	1.4E-05	6.5E-03
mercury	2.1E-11	8.6E-05	2.5E-07
silver	1.6E-10	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.8E-13	NA	NA
uranium-total	1.7E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
Hazard Quotient Sum =			6.5E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.2E-10	NA	NA
aroclor-1254	3.2E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.1E-10	1.5E+01	9.2E-09
beryllium	6.9E-11	8.4E+00	5.8E-10
benzo(a)pyrene	2.6E-12	6.1E+00	1.6E-11
cadmium	6.7E-11	6.3E+00	4.2E-10
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	3.5E-07	NA	NA
manganese	9.3E-08	NA	NA
mercury	2.1E-11	NA	NA
silver	1.6E-10	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.8E-13	6.0E-03	1.1E-15
uranium-total	1.7E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			1.0E-08

000276

Table H.V.2–12
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)			20 m^3/day
EF	Exposure frequency			350 days/year
EDn	Exposure duration			70 Year
Ca	Concentration of radionuclides in air			(see table below)
	Ra_{226+8d}	6.2E–08	pCi/m^3	pCi/m^3
	Rn_{222}	8.0E–01	pCi/m^3	pCi/m^3
	Sr_{90+1d}	2.4E–08	pCi/m^3	pCi/m^3
	Tc_{99}	3.3E–07	pCi/m^3	pCi/m^3
	Th_{230}	2.4E–07	pCi/m^3	pCi/m^3
	$Th_{232+10d}$	1.7E–09	pCi/m^3	pCi/m^3
	$U_{235/236}$	5.0E–09	pCi/m^3	pCi/m^3
	U_{238+2d}	1.6E–06	pCi/m^3	pCi/m^3
			pCi/m^3	pCi/m^3
			pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.0E–02	7.0E–09	2.1E–10
Rn_{222}	3.9E+05	7.3E–13	2.9E–07
Sr_{90+1d}	1.2E–02	6.2E–11	7.4E–13
Tc_{99}	1.6E–01	8.3E–12	1.4E–12
Th_{230}	1.2E–01	2.9E–08	3.5E–09
$Th_{232+10d}$	8.5E–04	1.1E–07	9.4E–11
$U_{235/236}$	2.4E–03	2.5E–08	6.1E–11
U_{238+2d}	7.7E–01	2.4E–08	1.9E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		3.1E–07

Table H.V.2–13
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.3E+00	mg/kg			mg/kg
arodor–1254	2.2E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	3.8E+00	mg/kg			mg/kg
beryllium	4.5E–01	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	4.9E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	2.2E+03	mg/kg			mg/kg
manganese	6.5E+02	mg/kg			mg/kg
mercury	5.5E–02	mg/kg			mg/kg
silver	4.8E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	2.0E–03	mg/kg			mg/kg
uranium–total	7.2E+00	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-13 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.2E-06	4.0E-04	8.0E-03
aroclor-1254	5.4E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.3E-06	3.0E-04	3.1E-02
beryllium	1.1E-06	5.0E-03	2.2E-04
benzo(a)pyrene	4.9E-08	NA	NA
cadmium	1.2E-06	1.0E-03	1.2E-03
1,2-dichloroethane	NA	NA	NA
magnesium	5.4E-03	9.7E+00	5.6E-04
manganese	1.6E-03	1.4E-01	1.1E-02
mercury	1.4E-07	3.0E-04	4.5E-04
silver	1.2E-06	5.0E-03	2.4E-04
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-09	6.0E-03	8.2E-07
uranium-total	1.8E-05	3.0E-03	5.9E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			5.9E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.2E-06	NA	NA
aroclor-1254	5.4E-08	7.7E+00	4.2E-07
aroclor-1260	NA	7.7E+00	
arsenic	9.3E-06	1.8E+00	1.6E-05
beryllium	1.1E-06	4.3E+00	4.8E-06
benzo(a)pyrene	4.9E-08	7.3E+00	3.6E-07
cadmium	1.2E-06	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	5.4E-03	NA	NA
manganese	1.6E-03	NA	NA
mercury	1.4E-07	NA	NA
silver	1.2E-06	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	4.9E-09	1.1E-02	5.4E-11
uranium-total	1.8E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			2.2E-05

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Table H.V.2–14
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	70 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}		pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.50E–05	pCi/mg	pCi/mg
Tc_{99}	2.50E–04	pCi/mg	pCi/mg
Th_{230}	2.65E–04	pCi/mg	pCi/mg
$Th_{232+10d}$		pCi/mg	pCi/mg
$U_{235/236}$	2.19E–05	pCi/mg	pCi/mg
U_{238+2d}	1.32E–03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	7.80E–10	NA
Rn_{222}	NA	1.40E–12	NA
Sr_{90+1d}	6.62E+01	3.60E–11	2.38E–09
Tc_{99}	1.10E+03	1.30E–12	1.43E–09
Th_{230}	1.17E+03	1.30E–11	1.52E–08
$Th_{232+10d}$	NA	1.70E–10	NA
$U_{235/236}$	9.66E+01	1.60E–11	1.55E–09
U_{238+2d}	5.82E+03	2.00E–11	1.16E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.37E–07

Table H.V.2–15
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E–02	1.30E+00	mg/kg		NA	mg/kg
arodor–1254	6.00E–02	2.20E–02	mg/kg		NA	mg/kg
arodor–1260	6.00E–02		mg/kg		NA	mg/kg
arsenic	1.00E–03	3.79E+00	mg/kg		NA	mg/kg
beryllium	1.00E–02	4.49E–01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E–01	2.00E–02	mg/kg		NA	mg/kg
cadmium	1.00E–02	4.90E–01	mg/kg		NA	mg/kg
1,2–dichloroethane	3.00E–01		mg/kg		NA	mg/kg
magnesium	1.00E–02	2.19E+03	mg/kg		NA	mg/kg
manganese	1.00E–02	6.47E+02	mg/kg		NA	mg/kg
mercury	5.00E–02	5.50E–02	mg/kg		NA	mg/kg
silver	1.00E–02	4.80E–01	mg/kg		NA	mg/kg
2,3,7,8–tcdd	3.00E–02		mg/kg		NA	mg/kg
trichloroethene	3.00E–01	2.00E–03	mg/kg		NA	mg/kg
uranium–total	1.00E–02	7.20E+00	mg/kg		NA	mg/kg
	NA		mg/kg			

References

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Table H.V.2-15 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.02E-06	6.00E-05	1.71E-02
aroclor-1254	1.04E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.99E-07	2.85E-04	1.05E-03
beryllium	3.54E-07	5.00E-03	7.07E-05
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	3.86E-07	5.00E-05	7.72E-03
1,2-dichloroethane	NA	NA	NA
magnesium	1.73E-03	4.85E-01	3.56E-03
manganese	5.10E-04	4.20E-03	1.21E-01
mercury	2.17E-07	4.50E-05	4.81E-03
silver	3.78E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.73E-08	5.88E-03	8.04E-06
uranium-total	5.67E-06	1.50E-04	3.78E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.93E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.02E-06	NA	NA
aroclor-1254	1.04E-07	1.03E+01	1.07E-06
aroclor-1260	NA	1.03E+01	
arsenic	2.99E-07	1.84E+00	5.50E-07
beryllium	3.54E-07	4.30E+00	1.52E-06
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	3.86E-07	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	1.73E-03	NA	NA
manganese	5.10E-04	NA	NA
mercury	2.17E-07	NA	NA
silver	3.78E-07	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	4.73E-08	1.12E-02	5.30E-10
uranium-total	5.67E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.14E-06

Table II.V.2-16
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	2.69E-04	mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	1.05E+00	mg/l			mg/l
manganese	6.38E-03	mg/l			mg/l
mercury	1.99E-06	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	5.61E-03	mg/l			mg/l
		mg/l			

References

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Table H.V.2-16 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.00E-04	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	7.36E-06	3.00E-04	2.45E-02
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	2.88E-02	9.70E+00	2.97E-03
manganese	1.75E-04	5.00E-03	3.49E-02
mercury	5.46E-08	3.00E-04	1.82E-04
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	1.54E-04	3.00E-03	5.12E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.14E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	7.36E-06	1.75E+00	1.29E-05
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	2.88E-02	NA	NA
manganese	1.75E-04	NA	NA
mercury	5.46E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	1.54E-04	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.29E-05

000724

Table H.V.2–17
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional Intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}		pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	5.4E–06	pCi/l	pCi/l
Tc_{99}	4.2E–01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	8.3E–02	pCi/l	pCi/l
U_{238+2d}	1.9E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	7.8E–10	NA
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.6E–01	3.6E–11	9.5E–12
Tc_{99}	2.0E+04	1.3E–12	2.7E–08
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	4.1E+03	1.6E–11	6.5E–08
U_{238+2d}	9.2E+04	2.0E–11	1.8E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.9E–06

Table H.V.2–18
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	25550	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1254	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1260	NA	mg/cm^2–day		NA	mg/cm^2–day
arsenic	6.72E–10	mg/cm^2–day		NA	mg/cm^2–day
beryllium	NA	mg/cm^2–day		NA	mg/cm^2–day
benzo(a)pyrene	NA	mg/cm^2–day		NA	mg/cm^2–day
cadmium	NA	mg/cm^2–day		NA	mg/cm^2–day
1,2–dichloroethane	NA	mg/cm^2–day		NA	mg/cm^2–day
magnesium	2.63E–06	mg/cm^2–day		NA	mg/cm^2–day
manganese	1.59E–08	mg/cm^2–day		NA	mg/cm^2–day
mercury	4.98E–12	mg/cm^2–day		NA	mg/cm^2–day
silver	NA	mg/cm^2–day		NA	mg/cm^2–day
2,3,7,8–tcdd	NA	mg/cm^2–day		NA	mg/cm^2–day
trichloroethene	NA	mg/cm^2–day		NA	mg/cm^2–day
uranium–total	1.40E–08	mg/cm^2–day		NA	mg/cm^2–day
	NA	mg/cm^2–day			

References

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Table H.V.2–18 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	6.00E–05	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.12E–07	2.85E–04	7.42E–04
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E–05	NA
1,2–dichloroethane	NA	NA	NA
magnesium	8.29E–04	4.85E–01	1.71E–03
manganese	5.02E–06	4.20E–03	1.20E–03
mercury	1.57E–09	4.50E–05	3.49E–05
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	5.88E–03	NA
uranium–total	4.42E–06	1.50E–04	2.94E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.31E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
arsenic	2.12E–07	1.84E+00	3.90E–07
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	1.01E–01	NA
magnesium	8.29E–04	NA	NA
manganese	5.02E–06	NA	NA
mercury	1.57E–09	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E–02	NA
uranium–total	4.42E–06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.90E–07

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Table H.V.2–19
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.4E–05	mg/kg			mg/kg
arodor–1254	6.7E–07	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	1.9E–05	mg/kg			mg/kg
beryllium	4.5E–07	mg/kg			mg/kg
benzo(a)pyrene	6.8E–07	mg/kg			mg/kg
cadmium	7.5E–06	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	5.5E–01	mg/kg			mg/kg
manganese	3.4E–03	mg/kg			mg/kg
mercury	6.3E–04	mg/kg			mg/kg
silver	3.0E–05	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	1.0E–09	mg/kg			mg/kg
uranium–total	1.4E–06	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-19 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.4E-08	4.0E-04	3.5E-05
aroclor-1254	6.9E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.9E-08	3.0E-04	6.5E-05
beryllium	4.6E-10	5.0E-03	9.2E-08
benzo(a)pyrene	7.0E-10	NA	NA
cadmium	7.8E-09	1.0E-03	7.8E-06
1,2-dichloroethane	NA	NA	NA
magnesium	5.7E-04	9.7E+00	5.9E-05
manganese	3.5E-06	1.4E-01	2.5E-05
mercury	6.4E-07	3.0E-04	2.1E-03
silver	3.0E-08	5.0E-03	6.1E-06
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.0E-12	6.0E-03	1.7E-10
uranium-total	1.4E-09	3.0E-03	4.8E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.3E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.4E-08	NA	NA
aroclor-1254	6.9E-10	7.7E+00	5.3E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	1.9E-08	1.8E+00	3.4E-08
beryllium	4.6E-10	4.3E+00	2.0E-09
benzo(a)pyrene	7.0E-10	7.3E+00	5.1E-09
cadmium	7.8E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	5.7E-04	NA	NA
manganese	3.5E-06	NA	NA
mercury	6.4E-07	NA	NA
silver	3.0E-08	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.0E-12	1.1E-02	1.1E-14
uranium-total	1.4E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.7E-08

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Table H.V.2–20
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	3.8E–09	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	5.6E–04	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	8.6E–07	pCi/kg	pCi/kg
$Th_{232+10d}$	9.5E–13	pCi/kg	pCi/kg
$U_{235/236}$	4.9E–06	pCi/kg	pCi/kg
U_{238+2d}	2.6E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.9E–06	7.8E–10	5.4E–15
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.0E+00	3.6E–11	3.7E–11
Tc_{99}	1.9E+03	1.3E–12	2.4E–09
Th_{230}	1.6E–03	1.3E–11	2.1E–14
$Th_{232+10d}$	1.7E–09	1.7E–10	3.0E–19
$U_{235/236}$	9.0E–03	1.6E–11	1.4E–13
U_{238+2d}	4.8E–01	2.0E–11	9.7E–12
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.5E–09

Table H.V.2-21
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.4E-03	mg/kg			mg/kg
arodor-1254	2.1E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	5.7E-04	mg/kg			mg/kg
beryllium	4.0E-07	mg/kg			mg/kg
benzo(a)pyrene	2.2E-04	mg/kg			mg/kg
cadmium	1.4E-02	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.4E+02	mg/kg			mg/kg
manganese	2.9E+00	mg/kg			mg/kg
mercury	1.1E-03	mg/kg			mg/kg
silver	2.0E-01	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.2E-07	mg/kg			mg/kg
uranium-total	4.2E-03	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-21 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.6E-06	4.0E-04	1.4E-02
aroclor-1254	8.7E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.3E-06	3.0E-04	7.8E-03
beryllium	1.7E-09	5.0E-03	3.3E-07
benzo(a)pyrene	8.8E-07	NA	NA
cadmium	5.6E-05	1.0E-03	5.6E-02
1,2-dichloroethane	NA	NA	NA
magnesium	1.8E+00	9.7E+00	1.9E-01
manganese	1.2E-02	1.4E-01	8.6E-02
mercury	4.6E-06	3.0E-04	1.5E-02
silver	8.1E-04	5.0E-03	1.6E-01
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.3E-09	6.0E-03	2.2E-07
uranium-total	1.7E-05	3.0E-03	5.8E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.4E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.6E-06	NA	NA
aroclor-1254	8.7E-07	7.7E+00	6.7E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	2.3E-06	1.8E+00	4.1E-06
beryllium	1.7E-09	4.3E+00	7.1E-09
benzo(a)pyrene	8.8E-07	7.3E+00	6.5E-06
cadmium	5.6E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.8E+00	NA	NA
manganese	1.2E-02	NA	NA
mercury	4.6E-06	NA	NA
silver	8.1E-04	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.3E-09	1.1E-02	1.4E-11
uranium-total	1.7E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.7E-05

Table H.V.2–22
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	6.8E–06	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.8E+00	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	7.2E–04	pCi/kg	pCi/kg
$Th_{232+10d}$	7.9E–10	pCi/kg	pCi/kg
$U_{235/236}$	1.5E–02	pCi/kg	pCi/kg
U_{238+2d}	8.0E–01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	5.0E–02	7.8E–10	3.9E–11
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.1E+04	3.6E–11	7.5E–07
Tc_{99}	8.7E+06	1.3E–12	1.1E–05
Th_{230}	5.3E+00	1.3E–11	6.9E–11
$Th_{232+10d}$	5.8E–06	1.7E–10	9.8E–16
$U_{235/236}$	1.1E+02	1.6E–11	1.8E–09
U_{238+2d}	5.9E+03	2.0E–11	1.2E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.2E–05

Table H.V.2-23
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.6E-01	mg/kg			mg/kg
arodor-1254	2.8E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	1.5E-01	mg/kg			mg/kg
beryllium	4.5E-03	mg/kg			mg/kg
benzo(a)pyrene	2.3E-04	mg/kg			mg/kg
cadmium	2.7E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	2.2E+03	mg/kg			mg/kg
manganese	1.6E+02	mg/kg			mg/kg
mercury	5.0E-02	mg/kg			mg/kg
silver	1.9E-01	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.2E-03	mg/kg			mg/kg
uranium-total	8.9E-02	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-23 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.2E-04	4.0E-04	5.4E-01
aroclor-1254	2.3E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.3E-04	3.0E-04	4.3E-01
beryllium	3.8E-06	5.0E-03	7.5E-04
benzo(a)pyrene	1.9E-07	NA	NA
cadmium	2.3E-04	1.0E-03	2.3E-01
1,2-dichloroethane	NA	NA	NA
magnesium	1.8E+00	9.7E+00	1.9E-01
manganese	1.4E-01	1.4E-01	9.7E-01
mercury	4.1E-05	3.0E-04	1.4E-01
silver	1.6E-04	5.0E-03	3.2E-02
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.7E-06	6.0E-03	4.4E-04
uranium-total	7.4E-05	3.0E-03	2.5E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.5E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.2E-04	NA	NA
aroclor-1254	2.3E-07	7.7E+00	1.8E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	1.3E-04	1.8E+00	2.2E-04
beryllium	3.8E-06	4.3E+00	1.6E-05
benzo(a)pyrene	1.9E-07	7.3E+00	1.4E-06
cadmium	2.3E-04	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.8E+00	NA	NA
manganese	1.4E-01	NA	NA
mercury	4.1E-05	NA	NA
silver	1.6E-04	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.7E-06	1.1E-02	2.9E-08
uranium-total	7.4E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.4E-04

SS2000

Table H.V.2-24
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables		0.122 kg/day
FI	Fraction ingested from contaminated source		0.5 (Unitless)
EF	Exposure frequency		350 days/year
EDn	Exposure duration		70 Year
Cv	Concentration of radionuclides in vegetables		

Ra_{226+8d}	2.7E-04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	3.7E+01	pCi/kg	pCi/kg
Tc_{99}	2.4E+03	pCi/kg	pCi/kg
Th_{230}	2.3E-01	pCi/kg	pCi/kg
$Th_{232+10d}$	2.2E-06	pCi/kg	pCi/kg
$U_{235/236}$	5.9E-01	pCi/kg	pCi/kg
U_{238+2d}	2.0E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	4.0E-01	7.8E-10	3.1E-10
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	5.6E+04	3.6E-11	2.0E-06
Tc_{99}	3.6E+06	1.3E-12	4.6E-06
Th_{230}	3.4E+02	1.3E-11	4.4E-09
$Th_{232+10d}$	3.3E-03	1.7E-10	5.7E-13
$U_{235/236}$	8.8E+02	1.6E-11	1.4E-08
U_{238+2d}	3.0E+04	2.0E-11	6.1E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		7.3E-06

Table H.V.2-25
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Adult)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	70 Year
ET_i	Fraction of day spent indoors	0.76 (unitless)
ET_o	Fraction of day spent outdoors	0.24 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	NA	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.50E-02	pCi/g	NA	pCi/g
Tc_{99}	2.50E-01	pCi/g	NA	pCi/g
Th_{230}	2.65E-01	pCi/g	NA	pCi/g
$Th_{232+10d}$	NA	pCi/g	NA	pCi/g
$U_{235/236}$	2.19E-02	pCi/g	NA	pCi/g
U_{238+2d}	1.32E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	6.0E-06	NA
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	6.2E-01	NA	
Tc_{99}	1.0E+01	6.0E-13	6.2E-12
Th_{230}	1.1E+01	5.4E-11	6.0E-10
$Th_{232+10d}$	NA	8.5E-06	NA
$U_{235/236}$	9.1E-01	2.4E-07	2.2E-07
U_{238+2d}	5.5E+01	5.1E-08	2.8E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		3.0E-06

Table H.V.2–26
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff–carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.2E–09	mg/m^3			mg/m^3
arodor–1254	1.2E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	2.2E–09	mg/m^3			mg/m^3
beryllium	2.5E–10	mg/m^3			mg/m^3
benzo(a)pyrene	9.3E–12	mg/m^3			mg/m^3
cadmium	2.4E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	1.3E–06	mg/m^3			mg/m^3
manganese	3.4E–07	mg/m^3			mg/m^3
mercury	7.7E–11	mg/m^3			mg/m^3
silver	6.0E–10	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	6.4E–13	mg/m^3			mg/m^3
uranium–total	6.3E–09	mg/m^3			mg/m^3
		mg/m^3			

Targets

000238

6349

Table H.V.2-26 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	9.0E-10	NA	NA
aroclor-1254	9.1E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.7E-09	NA	NA
beryllium	1.9E-10	NA	NA
benzo(a)pyrene	7.2E-12	NA	NA
cadmium	1.9E-10	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	9.9E-07	NA	NA
manganese	2.6E-07	1.4E-05	1.8E-02
mercury	5.9E-11	8.6E-05	6.9E-07
silver	4.6E-10	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-13	NA	NA
uranium-total	4.8E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
Hazard Quotient Sum =			1.8E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	7.7E-11	NA	NA
aroclor-1254	7.8E-13	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.5E-10	1.5E+01	2.2E-09
beryllium	1.7E-11	8.4E+00	1.4E-10
benzo(a)pyrene	6.1E-13	6.1E+00	3.7E-12
cadmium	1.6E-11	6.3E+00	1.0E-10
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	8.5E-08	NA	NA
manganese	2.2E-08	NA	NA
mercury	5.0E-12	NA	NA
silver	3.9E-11	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.2E-14	6.0E-03	2.5E-16
uranium-total	4.1E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			2.4E-09

C3000

Table H.V.2–27
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		12 m^3/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		6 Year
Ca	Concentration of radionuclides in air		(see table below)
	Ra_{226+8d}	6.2E–08 pCi/m^3	pCi/m^3
	Rn_{222}	8.0E–01 pCi/m^3	pCi/m^3
	Sr_{90+1d}	2.4E–08 pCi/m^3	pCi/m^3
	Tc_{99}	3.3E–07 pCi/m^3	pCi/m^3
	Th_{230}	2.4E–07 pCi/m^3	pCi/m^3
	$Th_{232+10d}$	1.7E–09 pCi/m^3	pCi/m^3
	$U_{235/236}$	5.0E–09 pCi/m^3	pCi/m^3
	U_{238+2d}	1.6E–06 pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E–03	7.0E–09	1.1E–11
Rn_{222}	2.0E+04	7.3E–13	1.5E–08
Sr_{90+1d}	6.1E–04	6.2E–11	3.8E–14
Tc_{99}	8.4E–03	8.3E–12	7.0E–14
Th_{230}	6.1E–03	2.9E–08	1.8E–10
$Th_{232+10d}$	4.4E–05	1.1E–07	4.8E–12
$U_{235/236}$	1.2E–04	2.5E–08	3.1E–12
U_{238+2d}	4.0E–02	2.4E–08	9.6E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.6E–08

Table H.V.2-28
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
CF	Conversion factor	1.0E-06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.3E+00	mg/kg			mg/kg
arodor-1254	2.2E-02	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	3.8E+00	mg/kg			mg/kg
beryllium	4.5E-01	mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium	4.9E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	2.2E+03	mg/kg			mg/kg
manganese	6.5E+02	mg/kg			mg/kg
mercury	5.5E-02	mg/kg			mg/kg
silver	4.8E-01	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	2.0E-03	mg/kg			mg/kg
uranium-total	7.2E+00	mg/kg			mg/kg
		mg/kg			

Targets

T-2000

Table H.V.2-28 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.7E-05	4.0E-04	4.2E-02
aroclor-1254	2.8E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	4.8E-05	3.0E-04	1.6E-01
beryllium	5.7E-06	5.0E-03	1.1E-03
benzo(a)pyrene	2.6E-07	NA	NA
cadmium	6.3E-06	1.0E-03	6.3E-03
1,2-dichloroethane	NA	NA	NA
magnesium	2.8E-02	9.7E+00	2.9E-03
manganese	8.3E-03	1.4E-01	5.9E-02
mercury	7.0E-07	3.0E-04	2.3E-03
silver	6.1E-06	5.0E-03	1.2E-03
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.6E-08	6.0E-03	4.3E-06
uranium-total	9.2E-05	3.0E-03	3.1E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			3.1E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.4E-06	NA	NA
aroclor-1254	2.4E-08	7.7E+00	1.9E-07
aroclor-1260	NA	7.7E+00	
arsenic	4.2E-06	1.8E+00	7.3E-06
beryllium	4.9E-07	4.3E+00	2.1E-06
benzo(a)pyrene	2.2E-08	7.3E+00	1.6E-07
cadmium	5.4E-07	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	2.4E-03	NA	NA
manganese	7.1E-04	NA	NA
mercury	6.0E-08	NA	NA
silver	5.3E-07	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	2.2E-09	1.1E-02	2.4E-11
uranium-total	7.9E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			9.7E-06

Table H.V.2-29
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)		200 mg/day
EF	Exposure frequency		350 days/year
EDn	Exposure Duration		6 Year
FI	Fractional Intake		1 (unitless)
CS	Concentration of radionuclides in soil		

Ra_{226+8d}		pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.50E-05	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	2.65E-04	pCi/mg	pCi/mg
$Th_{232+10d}$		pCi/mg	pCi/mg
$U_{235/236}$	2.19E-05	pCi/mg	pCi/mg
U_{238+2d}	1.32E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	7.80E-10	NA
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	6.30E+00	3.60E-11	2.27E-10
Tc_{99}	1.05E+02	1.30E-12	1.37E-10
Th_{230}	1.11E+02	1.30E-11	1.45E-09
$Th_{232+10d}$	NA	1.70E-10	NA
$U_{235/236}$	9.20E+00	1.60E-11	1.47E-10
U_{238+2d}	5.54E+02	2.00E-11	1.11E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.30E-08

Table H.V.2-30
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	2000 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E-06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E-02	1.30E+00	mg/kg		NA	mg/kg
arodor-1254	6.00E-02	2.20E-02	mg/kg		NA	mg/kg
arodor-1260	6.00E-02		mg/kg		NA	mg/kg
arsenic	1.00E-03	3.79E+00	mg/kg		NA	mg/kg
beryllium	1.00E-02	4.49E-01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E-01	2.00E-02	mg/kg		NA	mg/kg
cadmium	1.00E-02	4.90E-01	mg/kg		NA	mg/kg
1,2-dichloroethane	3.00E-01		mg/kg		NA	mg/kg
magnesium	1.00E-02	2.19E+03	mg/kg		NA	mg/kg
manganese	1.00E-02	6.47E+02	mg/kg		NA	mg/kg
mercury	5.00E-02	5.50E-02	mg/kg		NA	mg/kg
silver	1.00E-02	4.80E-01	mg/kg		NA	mg/kg
2,3,7,8-tcdd	3.00E-02		mg/kg		NA	mg/kg
trichloroethene	3.00E-01	2.00E-03	mg/kg		NA	mg/kg
uranium-total	1.00E-02	7.20E+00	mg/kg		NA	mg/kg
	NA		mg/kg			

Targets

000244

Table H.V.2-30 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.66E-06	6.00E-05	2.77E-02
aroclor-1254	1.69E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	4.85E-07	2.85E-04	1.70E-03
beryllium	5.74E-07	5.00E-03	1.15E-04
benzo(a)pyrene	7.67E-07	NA	NA
cadmium	6.26E-07	5.00E-05	1.25E-02
1,2-dichloroethane	NA	NA	NA
magnesium	2.80E-03	4.85E-01	5.77E-03
manganese	8.27E-04	4.20E-03	1.97E-01
mercury	3.52E-07	4.50E-05	7.81E-03
silver	6.14E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.67E-08	5.88E-03	1.30E-05
uranium-total	9.21E-06	1.50E-04	6.14E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.14E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.42E-07	NA	NA
aroclor-1254	1.45E-08	1.03E+01	1.49E-07
aroclor-1260	NA	1.03E+01	
arsenic	4.15E-08	1.84E+00	7.65E-08
beryllium	4.92E-08	4.30E+00	2.12E-07
benzo(a)pyrene	6.58E-08	NA	NA
cadmium	5.37E-08	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	2.40E-04	NA	NA
manganese	7.09E-05	NA	NA
mercury	3.01E-08	NA	NA
silver	5.26E-08	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	6.58E-09	1.12E-02	7.38E-11
uranium-total	7.89E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.37E-07

000245

Table H.V.2-31
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	2.69E-04	mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	1.05E+00	mg/l			mg/l
manganese	6.38E-03	mg/l			mg/l
mercury	1.99E-06	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	5.61E-03	mg/l			mg/l
		mg/l			

Targets

Table H.V.2-31 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.00E-04	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.72E-05	3.00E-04	5.72E-02
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	6.73E-02	9.70E+00	6.93E-03
manganese	4.08E-04	5.00E-03	8.15E-02
mercury	1.27E-07	3.00E-04	4.24E-04
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	3.58E-04	3.00E-03	1.19E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			2.66E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	1.47E-06	1.75E+00	2.58E-06
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	5.76E-03	NA	NA
manganese	3.49E-05	NA	NA
mercury	1.09E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	3.07E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			2.58E-06

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Table H.V.2–32
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional Intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}		pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	5.4E–06	pCi/l	pCi/l
Tc_{99}	4.2E–01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	8.3E–02	pCi/l	pCi/l
U_{238+2d}	1.9E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	7.8E–10	NA
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.1E–02	3.6E–11	4.1E–13
Tc_{99}	8.8E+02	1.3E–12	1.1E–09
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	1.7E+02	1.6E–11	2.8E–09
U_{238+2d}	3.9E+03	2.0E–11	7.9E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		8.2E–08

Table H.V.2-33
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2-day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for nOff-carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1254	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1260	NA	mg/cm^2-day		NA	mg/cm^2-day
arsenic	6.72E-10	mg/cm^2-day		NA	mg/cm^2-day
beryllium	NA	mg/cm^2-day		NA	mg/cm^2-day
benzo(a)pyrene	NA	mg/cm^2-day		NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day		NA	mg/cm^2-day
1,2-dichloroethane	NA	mg/cm^2-day		NA	mg/cm^2-day
magnesium	2.63E-06	mg/cm^2-day		NA	mg/cm^2-day
manganese	1.59E-08	mg/cm^2-day		NA	mg/cm^2-day
mercury	4.98E-12	mg/cm^2-day		NA	mg/cm^2-day
silver	NA	mg/cm^2-day		NA	mg/cm^2-day
2,3,7,8-tcdd	NA	mg/cm^2-day		NA	mg/cm^2-day
trichloroethene	NA	mg/cm^2-day		NA	mg/cm^2-day
uranium-total	1.40E-08	mg/cm^2-day		NA	mg/cm^2-day
	NA	mg/cm^2-day			

Targets

67.2000

Table H.V.2–33 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Dermal Contact while Bathing

Compound	HQ Calculation CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	6.00E–05	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	9.87E–07	2.85E–04	3.46E–03
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E–05	NA
1,2–dichloroethane	NA	NA	NA
magnesium	3.87E–03	4.85E–01	7.97E–03
manganese	2.34E–05	4.20E–03	5.58E–03
mercury	7.32E–09	4.50E–05	1.63E–04
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	5.88E–03	NA
uranium–total	2.06E–05	1.50E–04	1.37E–01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			1.55E–01

Compound	ILCR Calculation CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
arsenic	8.46E–08	1.84E+00	1.56E–07
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	1.01E–01	NA
magnesium	3.31E–04	NA	NA
manganese	2.01E–06	NA	NA
mercury	6.28E–10	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E–02	NA
uranium–total	1.77E–06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			1.56E–07

0007730

Table H.V.2-34
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039	kg/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for nOff-carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190	days
CS	Concentration of chemicals in meat		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.4E-05	mg/kg			mg/kg
arodor-1254	6.7E-07	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	1.9E-05	mg/kg			mg/kg
beryllium	4.5E-07	mg/kg			mg/kg
benzo(a)pyrene	6.8E-07	mg/kg			mg/kg
cadmium	7.5E-06	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	5.5E-01	mg/kg			mg/kg
manganese	3.4E-03	mg/kg			mg/kg
mercury	6.3E-04	mg/kg			mg/kg
silver	3.0E-05	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	1.0E-09	mg/kg			mg/kg
uranium-total	1.4E-06	mg/kg			mg/kg
		mg/kg			

Targets

Table H.V.2-34 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.6E-08	4.0E-04	6.4E-05
aroclor-1254	1.3E-09	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.5E-08	3.0E-04	1.2E-04
beryllium	8.4E-10	5.0E-03	1.7E-07
benzo(a)pyrene	1.3E-09	NA	NA
cadmium	1.4E-08	1.0E-03	1.4E-05
1,2-dichloroethane	NA	NA	NA
magnesium	1.0E-03	9.7E+00	1.1E-04
manganese	6.3E-06	1.4E-01	4.5E-05
mercury	1.2E-06	3.0E-04	3.9E-03
silver	5.5E-08	5.0E-03	1.1E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.9E-12	6.0E-03	3.1E-10
uranium-total	2.6E-09	3.0E-03	8.7E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.3E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.2E-09	NA	NA
aroclor-1254	1.1E-10	7.7E+00	8.3E-10
aroclor-1260	NA	7.7E+00	NA
arsenic	3.0E-09	1.8E+00	5.3E-09
beryllium	7.2E-11	4.3E+00	3.1E-10
benzo(a)pyrene	1.1E-10	7.3E+00	7.9E-10
cadmium	1.2E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	8.9E-05	NA	NA
manganese	5.4E-07	NA	NA
mercury	1.0E-07	NA	NA
silver	4.7E-09	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.6E-13	1.1E-02	1.8E-15
uranium-total	2.2E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		7.3E-09

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Table H.V.2-35
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	3.8E-09	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	5.6E-04	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	8.6E-07	pCi/kg	pCi/kg
$Th_{232+10d}$	9.5E-13	pCi/kg	pCi/kg
$U_{235/236}$	4.9E-06	pCi/kg	pCi/kg
U_{238+2d}	2.6E-04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.3E-07	7.8E-10	1.8E-16
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	3.5E-02	3.6E-11	1.2E-12
Tc_{99}	6.2E+01	1.3E-12	8.1E-11
Th_{230}	5.3E-05	1.3E-11	6.9E-16
$Th_{232+10d}$	5.8E-11	1.7E-10	9.9E-21
$U_{235/236}$	3.0E-04	1.6E-11	4.8E-15
U_{238+2d}	1.6E-02	2.0E-11	3.2E-13
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		8.2E-11

Table H.V.2-36
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.4E-03	mg/kg			mg/kg
arodor-1254	2.1E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	5.7E-04	mg/kg			mg/kg
beryllium	4.0E-07	mg/kg			mg/kg
benzo(a)pyrene	2.2E-04	mg/kg			mg/kg
cadmium	1.4E-02	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.4E+02	mg/kg			mg/kg
manganese	2.9E+00	mg/kg			mg/kg
mercury	1.1E-03	mg/kg			mg/kg
silver	2.0E-01	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.2E-07	mg/kg			mg/kg
uranium-total	4.2E-03	mg/kg			mg/kg
		mg/kg			

Targets

007254

Table H.V.2–36 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	5.9E–05	4.0E–04	1.5E–01
aroclor–1254	9.1E–06	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.5E–05	3.0E–04	8.2E–02
beryllium	1.7E–08	5.0E–03	3.5E–06
benzo(a)pyrene	9.3E–06	NA	NA
cadmium	5.9E–04	1.0E–03	5.9E–01
1,2–dichloroethane	NA	NA	NA
magnesium	1.9E+01	9.7E+00	2.0E+00
manganese	1.3E–01	1.4E–01	9.1E–01
mercury	4.9E–05	3.0E–04	1.6E–01
silver	8.5E–03	5.0E–03	1.7E+00
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	1.4E–08	6.0E–03	2.3E–06
uranium–total	1.8E–04	3.0E–03	6.0E–02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.6E+00

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	5.0E–06	NA	NA
aroclor–1254	7.8E–07	7.7E+00	6.0E–06
aroclor–1260	NA	7.7E+00	NA
arsenic	2.1E–06	1.8E+00	3.7E–06
beryllium	1.5E–09	4.3E+00	6.4E–09
benzo(a)pyrene	8.0E–07	7.3E+00	5.8E–06
cadmium	5.1E–05	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	1.6E+00	NA	NA
manganese	1.1E–02	NA	NA
mercury	4.2E–06	NA	NA
silver	7.3E–04	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.2E–09	1.1E–02	1.3E–11
uranium–total	1.6E–05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.6E–05

SS4000

Table H.V.2–37
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	6.8E–06	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.8E+00	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	7.2E–04	pCi/kg	pCi/kg
$Th_{232+10d}$	7.9E–10	pCi/kg	pCi/kg
$U_{235/236}$	1.5E–02	pCi/kg	pCi/kg
U_{238+2d}	8.0E–01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	9.6E–03	7.8E–10	7.5E–12
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	4.0E+03	3.6E–11	1.4E–07
Tc_{99}	1.7E+06	1.3E–12	2.2E–06
Th_{230}	1.0E+00	1.3E–11	1.3E–11
$Th_{232+10d}$	1.1E–06	1.7E–10	1.9E–16
$U_{235/236}$	2.1E+01	1.6E–11	3.4E–10
U_{238+2d}	1.1E+03	2.0E–11	2.3E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.4E–06

Table H.V.2-38
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for nOff-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for nOff-carcinogens (EDn x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.6E-01	mg/kg			mg/kg
arodor-1254	2.8E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	1.5E-01	mg/kg			mg/kg
beryllium	4.5E-03	mg/kg			mg/kg
benzo(a)pyrene	2.3E-04	mg/kg			mg/kg
cadmium	2.7E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	2.2E+03	mg/kg			mg/kg
manganese	1.6E+02	mg/kg			mg/kg
mercury	5.0E-02	mg/kg			mg/kg
silver	1.9E-01	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.2E-03	mg/kg			mg/kg
uranium-total	8.9E-02	mg/kg			mg/kg
		mg/kg			

Targets

000257

Table H.V.2-38 (continued)
Summary of Risk Quantitation (chemicals)
Target Receptor: Off-Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.8E-04	4.0E-04	2.2E+00
aroclor-1254	9.5E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	5.2E-04	3.0E-04	1.7E+00
beryllium	1.5E-05	5.0E-03	3.0E-03
benzo(a)pyrene	7.8E-07	NA	NA
cadmium	9.1E-04	1.0E-03	9.1E-01
1,2-dichloroethane	NA	NA	NA
magnesium	7.4E+00	9.7E+00	7.7E-01
manganese	5.5E-01	1.4E-01	3.9E+00
mercury	1.7E-04	3.0E-04	5.6E-01
silver	6.5E-04	5.0E-03	1.3E-01
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.1E-05	6.0E-03	1.8E-03
uranium-total	3.0E-04	3.0E-03	1.0E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.0E+01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	7.6E-05	NA	NA
aroclor-1254	8.1E-08	7.7E+00	6.2E-07
aroclor-1260	NA	7.7E+00	NA
arsenic	4.4E-05	1.8E+00	7.8E-05
beryllium	1.3E-06	4.3E+00	5.6E-06
benzo(a)pyrene	6.7E-08	7.3E+00	4.9E-07
cadmium	7.8E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	6.4E-01	NA	NA
manganese	4.7E-02	NA	NA
mercury	1.4E-05	NA	NA
silver	5.6E-05	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	9.2E-07	1.1E-02	1.0E-08
uranium-total	2.6E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		8.4E-05

000258

Table H.V.2–39
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	2.7E−04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	3.7E+01	pCi/kg	pCi/kg
Tc_{99}	2.4E+03	pCi/kg	pCi/kg
Th_{230}	2.3E−01	pCi/kg	pCi/kg
$Th_{232+10d}$	2.2E−06	pCi/kg	pCi/kg
$U_{235/236}$	5.9E−01	pCi/kg	pCi/kg
U_{238+2d}	2.0E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.0E−02	7.8E−10	2.3E−11
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	4.2E+03	3.6E−11	1.5E−07
Tc_{99}	2.6E+05	1.3E−12	3.4E−07
Th_{230}	2.5E+01	1.3E−11	3.3E−10
$Th_{232+10d}$	2.5E−04	1.7E−10	4.2E−14
$U_{235/236}$	6.6E+01	1.6E−11	1.1E−09
U_{238+2d}	2.3E+03	2.0E−11	4.5E−08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation	=	5.4E−07

Table H.V.2–40
Summary of Risk Quantitation (radionuclides)
Target Receptor: Off–Property Farm Resident (Child)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	6 Year
ET_i	Fraction of day spent indoors	0.92 (unitless)
ET_o	Fraction of day spent outdoors	0.08 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	NA	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.50E–02	pCi/g	NA	pCi/g
Tc_{99}	2.50E–01	pCi/g	NA	pCi/g
Th_{230}	2.65E–01	pCi/g	NA	pCi/g
$Th_{232+10d}$	NA	pCi/g	NA	pCi/g
$U_{235/236}$	2.19E–02	pCi/g	NA	pCi/g
U_{238+2d}	1.32E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	NA	6.0E–06	NA
Rn_{222}	NA	1.2E–09	NA
Sr_{90+1d}	4.7E–02	NA	
Tc_{99}	7.8E–01	6.0E–13	4.7E–13
Th_{230}	8.2E–01	5.4E–11	4.5E–11
$Th_{232+10d}$	NA	8.5E–06	NA
$U_{235/236}$	6.8E–02	2.4E–07	1.6E–08
U_{238+2d}	4.1E+00	5.1E–08	2.1E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.3E–07

Table H.V.2-41
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.8E-09	mg/m^3			mg/m^3
arodor-1254	5.3E-11	mg/m^3			mg/m^3
arodor-1260		mg/m^3			mg/m^3
arsenic	3.9E-09	mg/m^3			mg/m^3
beryllium	4.6E-10	mg/m^3			mg/m^3
benzo(a)pyrene	1.3E-11	mg/m^3			mg/m^3
cadmium	3.9E-10	mg/m^3			mg/m^3
1,2-dichloroethane		mg/m^3			mg/m^3
magnesium	5.7E-06	mg/m^3			mg/m^3
manganese	5.2E-07	mg/m^3			mg/m^3
mercury	1.7E-10	mg/m^3			mg/m^3
silver	1.3E-09	mg/m^3			mg/m^3
2,3,7,8-tcdd		mg/m^3			mg/m^3
trichloroethene	7.7E-13	mg/m^3			mg/m^3
uranium-total	1.2E-08	mg/m^3			mg/m^3
		mg/m^3			

References

Table H.V.2-41 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	7.6E-10	NA	NA
aroclor-1254	1.4E-11	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.1E-09	NA	NA
beryllium	1.2E-10	NA	NA
benzo(a)pyrene	3.5E-12	NA	NA
cadmium	1.1E-10	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	1.6E-06	NA	NA
manganese	1.4E-07	1.4E-05	1.0E-02
mercury	4.7E-11	8.6E-05	5.5E-07
silver	3.6E-10	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.1E-13	NA	NA
uranium-total	3.2E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		1.0E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	7.6E-10	NA	NA
aroclor-1254	1.4E-11	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.1E-09	1.5E+01	1.6E-08
beryllium	1.2E-10	8.4E+00	1.0E-09
benzo(a)pyrene	3.5E-12	6.1E+00	2.1E-11
cadmium	1.1E-10	6.3E+00	6.7E-10
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.6E-06	NA	NA
manganese	1.4E-07	NA	NA
mercury	4.7E-11	NA	NA
silver	3.6E-10	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.1E-13	6.0E-03	1.3E-15
uranium-total	3.2E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.8E-08

Table H.V.2-42
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On-Property Farm Resident (Adult)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		20 m^3/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		70 Year
Ca	Concentration of radionuclides in air		(see table below)

Ra_{226+8d}	7.9E-07	pCi/m^3	pCi/m^3
Rn_{222}	1.1E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	7.9E-08	pCi/m^3	pCi/m^3
Tc_{99}	1.6E-07	pCi/m^3	pCi/m^3
Th_{230}	8.4E-07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	8.0E-09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.2E-06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.9E-01	7.0E-09	2.7E-09
Rn_{222}	5.2E+06	7.3E-13	3.8E-06
Sr_{90+1d}	3.9E-02	6.2E-11	2.4E-12
Tc_{99}	7.8E-02	8.3E-12	6.5E-13
Th_{230}	4.1E-01	2.9E-08	1.2E-08
$Th_{232+10d}$	3.9E-03	1.1E-07	4.3E-10
$U_{235/236}$	NA	2.5E-08	NA
U_{238+2d}	1.6E+00	2.4E-08	3.7E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation		=	3.9E-06

Table H.V.2-43
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	180	mg/day
CF	Conversion factor	1.0E-06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in soil	(see table below)	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
aroclor-1254	2.5E-02	mg/kg			mg/kg
aroclor-1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E-01	mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium	6.0E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E-01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	7.6E-04	mg/kg			mg/kg
uranium-total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

Table H.V.2-43 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	9.8E-06	4.0E-04	2.4E-02
aroclor-1254	6.1E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.4E-05	3.0E-04	4.7E-02
beryllium	1.6E-06	5.0E-03	3.3E-04
benzo(a)pyrene	4.9E-08	NA	NA
cadmium	1.5E-06	1.0E-03	1.5E-03
1,2-dichloroethane	NA	NA	NA
magnesium	1.2E-02	9.7E+00	1.2E-03
manganese	2.0E-03	1.4E-01	1.4E-02
mercury	5.2E-07	3.0E-04	1.7E-03
silver	4.5E-06	5.0E-03	9.1E-04
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.9E-09	6.0E-03	3.1E-07
uranium-total	2.9E-05	3.0E-03	9.5E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.0E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	9.8E-06	NA	NA
aroclor-1254	6.1E-08	7.7E+00	4.7E-07
aroclor-1260	NA	7.7E+00	
arsenic	1.4E-05	1.8E+00	2.5E-05
beryllium	1.6E-06	4.3E+00	7.0E-06
benzo(a)pyrene	4.9E-08	7.3E+00	3.6E-07
cadmium	1.5E-06	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	1.2E-02	NA	NA
manganese	2.0E-03	NA	NA
mercury	5.2E-07	NA	NA
silver	4.5E-06	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	1.9E-09	1.1E-02	2.0E-11
uranium-total	2.9E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.3E-05

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Table H.V.2-44
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On-Property Farm Resident (Adult)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	180 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	70 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	3.84E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.19E-04	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	6.45E-04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.17E-05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.77E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.69E+03	7.80E-10	1.32E-06
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	5.25E+02	3.60E-11	1.89E-08
Tc_{99}	1.10E+03	1.30E-12	1.43E-09
Th_{230}	2.84E+03	1.30E-11	3.70E-08
$Th_{232+10d}$	1.40E+02	1.70E-10	2.38E-08
$U_{235/236}$	NA	1.60E-11	NA
U_{238+2d}	1.22E+04	2.00E-11	2.44E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation		=	1.65E-06

Table H.V.2-45
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E-06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E-02	3.97E+00	mg/kg		NA	mg/kg
arodor-1254	6.00E-02	2.46E-02	mg/kg		NA	mg/kg
arodor-1260	6.00E-02		mg/kg		NA	mg/kg
arsenic	1.00E-03	5.75E+00	mg/kg		NA	mg/kg
beryllium	1.00E-02	6.62E-01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E-01	2.00E-02	mg/kg		NA	mg/kg
cadmium	1.00E-02	5.96E-01	mg/kg		NA	mg/kg
1,2-dichloroethane	3.00E-01		mg/kg		NA	mg/kg
magnesium	1.00E-02	4.75E+03	mg/kg		NA	mg/kg
manganese	1.00E-02	8.12E+02	mg/kg		NA	mg/kg
mercury	5.00E-02	2.09E-01	mg/kg		NA	mg/kg
silver	1.00E-02	1.84E+00	mg/kg		NA	mg/kg
2,3,7,8-tcdd	3.00E-02		mg/kg		NA	mg/kg
trichloroethene	3.00E-01	7.55E-04	mg/kg		NA	mg/kg
uranium-total	1.00E-02	1.16E+01	mg/kg		NA	mg/kg
	NA		mg/kg			

References

29000

Table H.V.2-45 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.13E-06	6.00E-05	5.21E-02
aroclor-1254	1.16E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	4.53E-07	2.85E-04	1.59E-03
beryllium	5.21E-07	5.00E-03	1.04E-04
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	4.69E-07	5.00E-05	9.39E-03
1,2-dichloroethane	NA	NA	NA
magnesium	3.74E-03	4.85E-01	7.71E-03
manganese	6.40E-04	4.20E-03	1.52E-01
mercury	8.23E-07	4.50E-05	1.83E-02
silver	1.45E-06	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.78E-08	5.88E-03	3.03E-06
uranium-total	9.14E-06	1.50E-04	6.09E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.02E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.13E-06	NA	NA
aroclor-1254	1.16E-07	1.03E+01	1.19E-06
aroclor-1260	NA	1.03E+01	
arsenic	4.53E-07	1.84E+00	8.34E-07
beryllium	5.21E-07	4.30E+00	2.24E-06
benzo(a)pyrene	4.73E-07	NA	NA
cadmium	4.69E-07	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	3.74E-03	NA	NA
manganese	6.40E-04	NA	NA
mercury	8.23E-07	NA	NA
silver	1.45E-06	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	1.78E-08	1.12E-02	2.00E-10
uranium-total	9.14E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.27E-06

Table H.V.2–46
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor–1254		mg/l			mg/l
arodor–1260		mg/l			mg/l
arsenic	6.28E–07	mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2–dichloroethane		mg/l			mg/l
magnesium	6.69E–03	mg/l			mg/l
manganese	6.42E–02	mg/l			mg/l
mercury	2.66E–10	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8–tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium–total	9.02E–03	mg/l			mg/l
		mg/l			

References

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Table H.V.2-46 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	4.00E-04	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.72E-08	3.00E-04	5.74E-05
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	1.83E-04	9.70E+00	1.89E-05
manganese	1.76E-03	5.00E-03	3.52E-01
mercury	7.28E-12	3.00E-04	2.43E-08
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	2.47E-04	3.00E-03	8.24E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.34E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	1.72E-08	1.75E+00	3.01E-08
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	1.83E-04	NA	NA
manganese	1.76E-03	NA	NA
mercury	7.28E-12	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	2.47E-04	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.01E-08

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Table H.V.2–47
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}	3.3E–10	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	2.8E–02	pCi/l	pCi/l
Tc_{99}	1:7E+01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	1.3E–01	pCi/l	pCi/l
U_{238+2d}	3.0E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E–05	7.8E–10	1.3E–14
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	1.4E+03	3.6E–11	5.0E–08
Tc_{99}	8.2E+05	1.3E–12	1.1E–06
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	6.5E+03	1.6E–11	1.0E–07
U_{238+2d}	1.5E+05	2.0E–11	2.9E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 4.2E–06

Table H.V.2–48
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2–day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	25550	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1254	NA	mg/cm^2–day		NA	mg/cm^2–day
arodor–1260	NA	mg/cm^2–day		NA	mg/cm^2–day
arsenic	1.57E–12	mg/cm^2–day		NA	mg/cm^2–day
beryllium	NA	mg/cm^2–day		NA	mg/cm^2–day
benzo(a)pyrene	NA	mg/cm^2–day		NA	mg/cm^2–day
cadmium	NA	mg/cm^2–day		NA	mg/cm^2–day
1,2–dichloroethane	NA	mg/cm^2–day		NA	mg/cm^2–day
magnesium	1.67E–08	mg/cm^2–day		NA	mg/cm^2–day
manganese	1.61E–07	mg/cm^2–day		NA	mg/cm^2–day
mercury	6.64E–16	mg/cm^2–day		NA	mg/cm^2–day
silver	NA	mg/cm^2–day		NA	mg/cm^2–day
2,3,7,8–tcdd	NA	mg/cm^2–day		NA	mg/cm^2–day
trichloroethene	NA	mg/cm^2–day		NA	mg/cm^2–day
uranium–total	2.26E–08	mg/cm^2–day		NA	mg/cm^2–day
	NA	mg/cm^2–day			

References

Table H.V.2-48 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	6.00E-05	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	4.95E-10	2.85E-04	1.74E-06
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	5.27E-06	4.85E-01	1.09E-05
manganese	5.06E-05	4.20E-03	1.20E-02
mercury	2.09E-13	4.50E-05	4.65E-09
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	7.10E-06	1.50E-04	4.74E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.94E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	4.95E-10	1.84E+00	9.11E-10
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	5.27E-06	NA	NA
manganese	5.06E-05	NA	NA
mercury	2.09E-13	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	7.10E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		9.11E-10

Table H.V.2-49
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1	kg/day
FI	Fraction ingested from contaminated source	0.75	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	70	Year
EDc	Exposure duration for carcinogens	70	Year
BW	Body weight	70	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	25550	days
CS	Concentration of chemicals in meat		

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E-05	mg/kg			mg/kg
aroclor-1254	7.5E-07	mg/kg			mg/kg
aroclor-1260		mg/kg			mg/kg
arsenic	2.9E-05	mg/kg			mg/kg
beryllium	6.6E-07	mg/kg			mg/kg
benzo(a)pyrene	6.8E-07	mg/kg			mg/kg
cadmium	9.2E-06	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	1.2E+00	mg/kg			mg/kg
manganese	4.2E-03	mg/kg			mg/kg
mercury	2.4E-03	mg/kg			mg/kg
silver	1.1E-04	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.8E-10	mg/kg			mg/kg
uranium-total	2.2E-06	mg/kg			mg/kg
		mg/kg			

References

Table H.V.2–49 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	4.3E–08	4.0E–04	1.1E–04
aroclor–1254	7.7E–10	NA	NA
aroclor–1260	NA	NA	NA
arsenic	3.0E–08	3.0E–04	9.8E–05
beryllium	6.8E–10	5.0E–03	1.4E–07
benzo(a)pyrene	7.0E–10	NA	NA
cadmium	9.4E–09	1.0E–03	9.4E–06
1,2–dichloroethane	NA	NA	NA
magnesium	1.2E–03	9.7E+00	1.3E–04
manganese	4.3E–06	1.4E–01	3.1E–05
mercury	2.4E–06	3.0E–04	8.1E–03
silver	1.2E–07	5.0E–03	2.3E–05
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	3.9E–13	6.0E–03	6.5E–11
uranium–total	2.3E–09	3.0E–03	7.7E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			8.5E–03

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	4.3E–08	NA	NA
aroclor–1254	7.7E–10	7.7E+00	5.9E–09
aroclor–1260	NA	7.7E+00	NA
arsenic	3.0E–08	1.8E+00	5.2E–08
beryllium	6.8E–10	4.3E+00	2.9E–09
benzo(a)pyrene	7.0E–10	7.3E+00	5.1E–09
cadmium	9.4E–09	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	1.2E–03	NA	NA
manganese	4.3E–06	NA	NA
mercury	2.4E–06	NA	NA
silver	1.2E–07	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	3.9E–13	1.1E–02	4.3E–15
uranium–total	2.3E–09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			6.6E–08

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Table H.V.2–50
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	1.2E–04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	4.5E–03	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	2.1E–06	pCi/kg	pCi/kg
$Th_{232+10d}$	1.0E–07	pCi/kg	pCi/kg
$U_{235/236}$	1.3E–06	pCi/kg	pCi/kg
U_{238+2d}	5.4E–04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.2E–01	7.8E–10	1.7E–10
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	8.2E+00	3.6E–11	3.0E–10
Tc_{99}	1.9E+03	1.3E–12	2.4E–09
Th_{230}	3.9E–03	1.3E–11	5.0E–14
$Th_{232+10d}$	1.9E–04	1.7E–10	3.2E–14
$U_{235/236}$	2.4E–03	1.6E–11	3.9E–14
U_{238+2d}	1.0E+00	2.0E–11	2.0E–11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.9E–09

Table II.V.2-51
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E-03	mg/kg			mg/kg
arodor-1254	2.4E-04	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	8.6E-04	mg/kg			mg/kg
beryllium	6.0E-07	mg/kg			mg/kg
benzo(a)pyrene	2.2E-04	mg/kg			mg/kg
cadmium	1.7E-02	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	9.6E+02	mg/kg			mg/kg
manganese	3.7E+00	mg/kg			mg/kg
mercury	4.3E-03	mg/kg			mg/kg
silver	7.5E-01	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	1.2E-07	mg/kg			mg/kg
uranium-total	6.8E-03	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-51 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.7E-05	4.0E-04	4.3E-02
aroclor-1254	9.7E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.5E-06	3.0E-04	1.2E-02
beryllium	2.4E-09	5.0E-03	4.9E-07
benzo(a)pyrene	8.8E-07	NA	NA
cadmium	6.9E-05	1.0E-03	6.9E-02
1,2-dichloroethane	NA	NA	NA
magnesium	3.9E+00	9.7E+00	4.1E-01
manganese	1.5E-02	1.4E-01	1.1E-01
mercury	1.8E-05	3.0E-04	5.9E-02
silver	3.1E-03	5.0E-03	6.2E-01
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-10	6.0E-03	8.2E-08
uranium-total	2.8E-05	3.0E-03	9.3E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.3E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.7E-05	NA	NA
aroclor-1254	9.7E-07	7.7E+00	7.5E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	3.5E-06	1.8E+00	6.2E-06
beryllium	2.4E-09	4.3E+00	1.1E-08
benzo(a)pyrene	8.8E-07	7.3E+00	6.5E-06
cadmium	6.9E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	3.9E+00	NA	NA
manganese	1.5E-02	NA	NA
mercury	1.8E-05	NA	NA
silver	3.1E-03	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.9E-10	1.1E-02	5.4E-12
uranium-total	2.8E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.0E-05

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Table H.V.2-52
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	2.2E-01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.2E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	1.7E-03	pCi/kg	pCi/kg
$Th_{232+10d}$	8.6E-05	pCi/kg	pCi/kg
$U_{235/236}$	4.8E-03	pCi/kg	pCi/kg
U_{238+2d}	1.6E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E+03	7.8E-10	1.2E-06
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	1.6E+05	3.6E-11	5.9E-06
Tc_{99}	8.8E+06	1.3E-12	1.1E-05
Th_{230}	1.3E+01	1.3E-11	1.7E-10
$Th_{232+10d}$	6.3E-01	1.7E-10	1.1E-10
$U_{235/236}$	3.5E+01	1.6E-11	5.6E-10
U_{238+2d}	1.2E+04	2.0E-11	2.4E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.9E-05

Table H.V.2–53
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	7.9E–01	mg/kg			mg/kg
arodor–1254	3.1E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	2.3E–01	mg/kg			mg/kg
beryllium	6.6E–03	mg/kg			mg/kg
benzo(a)pyrene	2.3E–04	mg/kg			mg/kg
cadmium	3.3E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	2.0E+02	mg/kg			mg/kg
mercury	1.9E–01	mg/kg			mg/kg
silver	7.4E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	1.2E–03	mg/kg			mg/kg
uranium–total	1.4E–01	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-53 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	6.6E-04	4.0E-04	1.7E+00
aroclor-1254	2.6E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.9E-04	3.0E-04	6.4E-01
beryllium	5.5E-06	5.0E-03	1.1E-03
benzo(a)pyrene	1.9E-07	NA	NA
cadmium	2.7E-04	1.0E-03	2.7E-01
1,2-dichloroethane	NA	NA	NA
magnesium	4.0E+00	9.7E+00	4.1E-01
manganese	1.7E-01	1.4E-01	1.2E+00
mercury	1.6E-04	3.0E-04	5.2E-01
silver	6.2E-04	5.0E-03	1.2E-01
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.0E-06	6.0E-03	1.7E-04
uranium-total	1.2E-04	3.0E-03	4.0E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.9E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.6E-04	NA	NA
aroclor-1254	2.6E-07	7.7E+00	2.0E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	1.9E-04	1.8E+00	3.4E-04
beryllium	5.5E-06	4.3E+00	2.4E-05
benzo(a)pyrene	1.9E-07	7.3E+00	1.4E-06
cadmium	2.7E-04	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	4.0E+00	NA	NA
manganese	1.7E-01	NA	NA
mercury	1.6E-04	NA	NA
silver	6.2E-04	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.0E-06	1.1E-02	1.1E-08
uranium-total	1.2E-04	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.6E-04

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Table H.V.2–54
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Adult)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	5.8E+00	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	3.0E+02	pCi/kg	pCi/kg
Tc_{99}	2.5E+03	pCi/kg	pCi/kg
Th_{230}	5.5E–01	pCi/kg	pCi/kg
$Th_{232+10d}$	2.7E–02	pCi/kg	pCi/kg
$U_{235/236}$	6.5E–01	pCi/kg	pCi/kg
U_{238+2d}	3.8E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	8.6E+03	7.8E–10	6.7E–06
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	4.4E+05	3.6E–11	1.6E–05
Tc_{99}	3.7E+06	1.3E–12	4.8E–06
Th_{230}	8.2E+02	1.3E–11	1.1E–08
$Th_{232+10d}$	4.0E+01	1.7E–10	6.8E–09
$U_{235/236}$	9.7E+02	1.6E–11	1.6E–08
U_{238+2d}	5.7E+04	2.0E–11	1.1E–06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.9E–05

Table H.V.2-55
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On-Property Farm Resident (Adult)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	70 Year
ET_i	Fraction of day spent indoors	0.76 (unitless)
ET_o	Fraction of day spent outdoors	0.24 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	3.84E-01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.19E-01	pCi/g	NA	pCi/g
Tc_{99}	2.50E-01	pCi/g	NA	pCi/g
Th_{230}	6.45E-01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.17E-02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.77E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E+01	6.0E-06	9.6E-05
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	5.0E+00	NA	
Tc_{99}	1.0E+01	6.0E-13	6.2E-12
Th_{230}	2.7E+01	5.4E-11	1.5E-09
$Th_{232+10d}$	1.3E+00	8.5E-06	1.1E-05
$U_{235/236}$	NA	2.4E-07	NA
U_{238+2d}	1.2E+02	5.1E-08	5.9E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.1E-04

Table H.V.2–56
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.8E–09	mg/m^3			mg/m^3
arodor–1254	5.3E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	3.9E–09	mg/m^3			mg/m^3
beryllium	4.6E–10	mg/m^3			mg/m^3
benzo(a)pyrene	1.3E–11	mg/m^3			mg/m^3
cadmium	3.9E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	5.7E–06	mg/m^3			mg/m^3
manganese	5.2E–07	mg/m^3			mg/m^3
mercury	1.7E–10	mg/m^3			mg/m^3
silver	1.3E–09	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	7.7E–13	mg/m^3			mg/m^3
uranium–total	1.2E–08	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.V.2-56 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.1E-09	NA	NA
aroclor-1254	4.0E-11	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.0E-09	NA	NA
beryllium	3.5E-10	NA	NA
benzo(a)pyrene	9.8E-12	NA	NA
cadmium	3.0E-10	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	4.4E-06	NA	NA
manganese	4.0E-07	1.4E-05	2.8E-02
mercury	1.3E-10	8.6E-05	1.5E-06
silver	1.0E-09	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	5.9E-13	NA	NA
uranium-total	8.9E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		2.8E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.8E-10	NA	NA
aroclor-1254	3.5E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.5E-10	1.5E+01	3.8E-09
beryllium	3.0E-11	8.4E+00	2.5E-10
benzo(a)pyrene	8.4E-13	6.1E+00	5.1E-12
cadmium	2.6E-11	6.3E+00	1.6E-10
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	3.8E-07	NA	NA
manganese	3.4E-08	NA	NA
mercury	1.1E-11	NA	NA
silver	8.7E-11	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	5.1E-14	6.0E-03	3.0E-16
uranium-total	7.6E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.2E-09

582000

Table H.V.2–57
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		12 m^3/day
EF	Exposure frequency		350 days/year
EDn	Exposure duration		6 Year
Ca	Concentration of radionuclides in air		(see table below)

Ra_{226+8d}	7.9E–07	pCi/m^3	pCi/m^3
Rn_{222}	1.1E+01	pCi/m^3	pCi/m^3
Sr_{90+1d}	7.9E–08	pCi/m^3	pCi/m^3
Tc_{99}	1.6E–07	pCi/m^3	pCi/m^3
Th_{230}	8.4E–07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	8.0E–09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.2E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.0E–02	7.0E–09	1.4E–10
Rn_{222}	2.7E+05	7.3E–13	2.0E–07
Sr_{90+1d}	2.0E–03	6.2E–11	1.2E–13
Tc_{99}	4.0E–03	8.3E–12	3.3E–14
Th_{230}	2.1E–02	2.9E–08	6.2E–10
$Th_{232+10d}$	2.0E–04	1.1E–07	2.2E–11
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	8.0E–02	2.4E–08	1.9E–09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.0E–07

Table H.V.2–58
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
arodor–1254	2.5E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E–01	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	6.0E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E–01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-58 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.1E-05	4.0E-04	1.3E-01
aroclor-1254	3.1E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	7.4E-05	3.0E-04	2.5E-01
beryllium	8.5E-06	5.0E-03	1.7E-03
benzo(a)pyrene	2.6E-07	NA	NA
cadmium	7.6E-06	1.0E-03	7.6E-03
1,2-dichloroethane	NA	NA	NA
magnesium	6.1E-02	9.7E+00	6.3E-03
manganese	1.0E-02	1.4E-01	7.4E-02
mercury	2.7E-06	3.0E-04	8.9E-03
silver	2.4E-05	5.0E-03	4.7E-03
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	9.7E-09	6.0E-03	1.6E-06
uranium-total	1.5E-04	3.0E-03	4.9E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.2E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	4.4E-06	NA	NA
aroclor-1254	2.7E-08	7.7E+00	2.1E-07
aroclor-1260	NA	7.7E+00	
arsenic	6.3E-06	1.8E+00	1.1E-05
beryllium	7.3E-07	4.3E+00	3.1E-06
benzo(a)pyrene	2.2E-08	7.3E+00	1.6E-07
cadmium	6.5E-07	NA	NA
1,2-dichloroethane	NA	9.1E-02	
magnesium	5.2E-03	NA	NA
manganese	8.9E-04	NA	NA
mercury	2.3E-07	NA	NA
silver	2.0E-06	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	
trichloroethene	8.3E-10	1.1E-02	9.1E-12
uranium-total	1.3E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.5E-05

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Table H.V.2-59
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On-Property Farm Resident (Child)
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	200 mg/day
EF	Exposure frequency	350 days/year
EDn	Exposure Duration	6 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	3.84E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.19E-04	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	6.45E-04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.17E-05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.77E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.61E+02	7.80E-10	1.26E-07
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	5.00E+01	3.60E-11	1.80E-09
Tc_{99}	1.05E+02	1.30E-12	1.37E-10
Th_{230}	2.71E+02	1.30E-11	3.52E-09
$Th_{232+10d}$	1.33E+01	1.70E-10	2.26E-09
$U_{235/236}$	NA	1.60E-11	NA
U_{238+2d}	1.16E+03	2.00E-11	2.33E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.57E-07

Table H.V.2–60
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	2000	cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1	mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv	
CF	Conversion factor	1E–06	kg/mg
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non–carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non–carcinogens (EDn x365)	2190	days
CS	Concentration of chemicals in soil		

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E–02	3.97E+00	mg/kg		NA	mg/kg
arodor–1254	6.00E–02	2.46E–02	mg/kg		NA	mg/kg
arodor–1260	6.00E–02		mg/kg		NA	mg/kg
arsenic	1.00E–03	5.75E+00	mg/kg		NA	mg/kg
beryllium	1.00E–02	6.62E–01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E–01	2.00E–02	mg/kg		NA	mg/kg
cadmium	1.00E–02	5.96E–01	mg/kg		NA	mg/kg
1,2–dichloroethane	3.00E–01		mg/kg		NA	mg/kg
magnesium	1.00E–02	4.75E+03	mg/kg		NA	mg/kg
manganese	1.00E–02	8.12E+02	mg/kg		NA	mg/kg
mercury	5.00E–02	2.09E–01	mg/kg		NA	mg/kg
silver	1.00E–02	1.84E+00	mg/kg		NA	mg/kg
2,3,7,8–tcdd	3.00E–02		mg/kg		NA	mg/kg
trichloroethene	3.00E–01	7.55E–04	mg/kg		NA	mg/kg
uranium–total	1.00E–02	1.16E+01	mg/kg		NA	mg/kg
	NA		mg/kg			

References

000750

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Table H.V.2-60 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Dermal Contact with Soil

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.08E-06	6.00E-05	8.46E-02
aroclor-1254	1.89E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	7.35E-07	2.85E-04	2.58E-03
beryllium	8.46E-07	5.00E-03	1.69E-04
benzo(a)pyrene	7.67E-07	NA	NA
cadmium	7.62E-07	5.00E-05	1.52E-02
1,2-dichloroethane	NA	NA	NA
magnesium	6.07E-03	4.85E-01	1.25E-02
manganese	1.04E-03	4.20E-03	2.47E-01
mercury	1.34E-06	4.50E-05	2.97E-02
silver	2.35E-06	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.90E-08	5.88E-03	4.92E-06
uranium-total	1.48E-05	1.50E-04	9.89E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			4.91E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	4.35E-07	NA	NA
aroclor-1254	1.62E-08	1.03E+01	1.66E-07
aroclor-1260	NA	1.03E+01	
arsenic	6.30E-08	1.84E+00	1.16E-07
beryllium	7.25E-08	4.30E+00	3.12E-07
benzo(a)pyrene	6.58E-08	NA	NA
cadmium	6.53E-08	NA	NA
1,2-dichloroethane	NA	1.01E-01	
magnesium	5.21E-04	NA	NA
manganese	8.90E-05	NA	NA
mercury	1.15E-07	NA	NA
silver	2.02E-07	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	
trichloroethene	2.48E-09	1.12E-02	2.79E-11
uranium-total	1.27E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			5.94E-07

0006954

Table H.V.2-61
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Drinking Water Ingestion

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony		mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	6.28E-07	mg/l			mg/l
beryllium		mg/l			mg/l
benzo(a)pyrene		mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	6.69E-03	mg/l			mg/l
manganese	6.42E-02	mg/l			mg/l
mercury	2.66E-10	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	9.02E-03	mg/l			mg/l
		mg/l			

References

Table H.V.2–61 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	NA	4.00E–04	NA
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	4.02E–08	3.00E–04	1.34E–04
beryllium	NA	5.00E–03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	1.00E–03	NA
1,2–dichloroethane	NA	NA	NA
magnesium	4.28E–04	9.70E+00	4.41E–05
manganese	4.10E–03	5.00E–03	8.21E–01
mercury	1.70E–11	3.00E–04	5.66E–08
silver	NA	5.00E–03	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	6.00E–03	NA
uranium–total	5.77E–04	3.00E–03	1.92E–01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.01E+00

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor–1254	NA	7.70E+00	NA
aroclor–1260	NA	7.70E+00	NA
arsenic	3.44E–09	1.75E+00	6.02E–09
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	7.30E+00	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	9.10E–02	NA
magnesium	3.67E–05	NA	NA
manganese	3.52E–04	NA	NA
mercury	1.46E–12	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E–02	NA
uranium–total	4.94E–05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.02E–09

Table H.V.2–62
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Drinking Water

Risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	1 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}	3.3E–10	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	2.8E–02	pCi/l	pCi/l
Tc_{99}	1.7E+01	pCi/l	pCi/l
Th_{230}		pCi/l	pCi/l
$Th_{232+10d}$		pCi/l	pCi/l
$U_{235/236}$	1.3E–01	pCi/l	pCi/l
U_{238+2d}	3.0E+00	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.9E–07	7.8E–10	5.4E–16
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	5.9E+01	3.6E–11	2.1E–09
Tc_{99}	3.5E+04	1.3E–12	4.6E–08
Th_{230}	NA	1.3E–11	NA
$Th_{232+10d}$	NA	1.7E–10	NA
$U_{235/236}$	2.8E+02	1.6E–11	4.5E–09
U_{238+2d}	6.3E+03	2.0E–11	1.3E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.8E–07

Table H.V.2-63
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Dermal Contact while Bathing

Risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv	mg/cm^2-day
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	2190	days
SA	Skin surface area available for contact	23000	cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1254	NA	mg/cm^2-day		NA	mg/cm^2-day
arodor-1260	NA	mg/cm^2-day		NA	mg/cm^2-day
arsenic	1.57E-12	mg/cm^2-day		NA	mg/cm^2-day
beryllium	NA	mg/cm^2-day		NA	mg/cm^2-day
benzo(a)pyrene	NA	mg/cm^2-day		NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day		NA	mg/cm^2-day
1,2-dichloroethane	NA	mg/cm^2-day		NA	mg/cm^2-day
magnesium	1.67E-08	mg/cm^2-day		NA	mg/cm^2-day
manganese	1.61E-07	mg/cm^2-day		NA	mg/cm^2-day
mercury	6.64E-16	mg/cm^2-day		NA	mg/cm^2-day
silver	NA	mg/cm^2-day		NA	mg/cm^2-day
2,3,7,8-tcdd	NA	mg/cm^2-day		NA	mg/cm^2-day
trichloroethene	NA	mg/cm^2-day		NA	mg/cm^2-day
uranium-total	2.26E-08	mg/cm^2-day		NA	mg/cm^2-day
	NA	mg/cm^2-day			

References

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Table H.V.2-63 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Dermal Contact while Bathing

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	NA	6.00E-05	NA
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.31E-09	2.85E-04	8.10E-06
beryllium	NA	5.00E-03	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	2.46E-05	4.85E-01	5.07E-05
manganese	2.36E-04	4.20E-03	5.62E-02
mercury	9.76E-13	4.50E-05	2.17E-08
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	3.32E-05	1.50E-04	2.21E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.77E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	NA	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	1.98E-10	1.84E+00	3.65E-10
beryllium	NA	4.30E+00	NA
benzo(a)pyrene	NA	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	2.11E-06	NA	NA
manganese	2.02E-05	NA	NA
mercury	8.37E-14	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	2.84E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.65E-10

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Table H.V.2–64
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E–05	mg/kg			mg/kg
arodor–1254	7.5E–07	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	2.9E–05	mg/kg			mg/kg
beryllium	6.6E–07	mg/kg			mg/kg
benzo(a)pyrene	6.8E–07	mg/kg			mg/kg
cadmium	9.2E–06	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	1.2E+00	mg/kg			mg/kg
manganese	4.2E–03	mg/kg			mg/kg
mercury	2.4E–03	mg/kg			mg/kg
silver	1.1E–04	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	3.8E–10	mg/kg			mg/kg
uranium–total	2.2E–06	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-64 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	7.8E-08	4.0E-04	1.9E-04
aroclor-1254	1.4E-09	NA	NA
aroclor-1260	NA	NA	NA
arsenic	5.4E-08	3.0E-04	1.8E-04
beryllium	1.2E-09	5.0E-03	2.5E-07
benzo(a)pyrene	1.3E-09	NA	NA
cadmium	1.7E-08	1.0E-03	1.7E-05
1,2-dichloroethane	NA	NA	NA
magnesium	2.2E-03	9.7E+00	2.3E-04
manganese	7.9E-06	1.4E-01	5.6E-05
mercury	4.4E-06	3.0E-04	1.5E-02
silver	2.1E-07	5.0E-03	4.2E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.1E-13	6.0E-03	1.2E-10
uranium-total	4.2E-09	3.0E-03	1.4E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.6E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.7E-09	NA	NA
aroclor-1254	1.2E-10	7.7E+00	9.3E-10
aroclor-1260	NA	7.7E+00	NA
arsenic	4.6E-09	1.8E+00	8.1E-09
beryllium	1.1E-10	4.3E+00	4.6E-10
benzo(a)pyrene	1.1E-10	7.3E+00	7.9E-10
cadmium	1.5E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.9E-04	NA	NA
manganese	6.8E-07	NA	NA
mercury	3.8E-07	NA	NA
silver	1.8E-08	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	6.0E-14	1.1E-02	6.7E-16
uranium-total	3.6E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.0E-08

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Table H.V.2-65
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Meat Products

Risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.039 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	1.2E-04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	4.5E-03	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	2.1E-06	pCi/kg	pCi/kg
$Th_{232+10d}$	1.0E-07	pCi/kg	pCi/kg
$U_{235/236}$	1.3E-06	pCi/kg	pCi/kg
U_{238+2d}	5.4E-04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	7.4E-03	7.8E-10	5.8E-12
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	2.7E-01	3.6E-11	9.9E-12
Tc_{99}	6.3E+01	1.3E-12	8.1E-11
Th_{230}	1.3E-04	1.3E-11	1.7E-15
$Th_{232+10d}$	6.3E-06	1.7E-10	1.1E-15
$U_{235/236}$	8.2E-05	1.6E-11	1.3E-15
U_{238+2d}	3.3E-02	2.0E-11	6.7E-13
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 9.8E-11

Table H.V.2–66
Summary of Risk Quantitation (chemicals)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation $\bullet = \frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	6 Year
EDc	Exposure duration for carcinogens	6 Year
BW	Body weight	15 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E–03	mg/kg			mg/kg
arodor–1254	2.4E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	8.6E–04	mg/kg			mg/kg
beryllium	6.0E–07	mg/kg			mg/kg
benzo(a)pyrene	2.2E–04	mg/kg			mg/kg
cadmium	1.7E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	9.6E+02	mg/kg			mg/kg
manganese	3.7E+00	mg/kg			mg/kg
mercury	4.3E–03	mg/kg			mg/kg
silver	7.5E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	1.2E–07	mg/kg			mg/kg
uranium–total	6.8E–03	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-66 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.8E-04	4.0E-04	4.5E-01
aroclor-1254	1.0E-05	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.7E-05	3.0E-04	1.2E-01
beryllium	2.6E-08	5.0E-03	5.1E-06
benzo(a)pyrene	9.3E-06	NA	NA
cadmium	7.2E-04	1.0E-03	7.2E-01
1,2-dichloroethane	NA	NA	NA
magnesium	4.1E+01	9.7E+00	4.3E+00
manganese	1.6E-01	1.4E-01	1.1E+00
mercury	1.8E-04	3.0E-04	6.2E-01
silver	3.3E-02	5.0E-03	6.5E+00
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	5.2E-09	6.0E-03	8.6E-07
uranium-total	2.9E-04	3.0E-03	9.7E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.4E+01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.5E-05	NA	NA
aroclor-1254	8.8E-07	7.7E+00	6.8E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	3.2E-06	1.8E+00	5.6E-06
beryllium	2.2E-09	4.3E+00	9.5E-09
benzo(a)pyrene	8.0E-07	7.3E+00	5.8E-06
cadmium	6.2E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	3.5E+00	NA	NA
manganese	1.4E-02	NA	NA
mercury	1.6E-05	NA	NA
silver	2.8E-03	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.4E-10	1.1E-02	4.9E-12
uranium-total	2.5E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.8E-05

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Table H.V.2–67
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Dairy Products

Risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.9 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	2.2E–01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.2E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	1.7E–03	pCi/kg	pCi/kg
$Th_{232+10d}$	8.6E–05	pCi/kg	pCi/kg
$U_{235/236}$	4.8E–03	pCi/kg	pCi/kg
U_{238+2d}	1.6E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.1E+02	7.8E–10	2.4E–07
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	3.2E+04	3.6E–11	1.1E–06
Tc_{99}	1.7E+06	1.3E–12	2.2E–06
Th_{230}	2.5E+00	1.3E–11	3.2E–11
$Th_{232+10d}$	1.2E–01	1.7E–10	2.1E–11
$U_{235/236}$	6.8E+00	1.6E–11	1.1E–10
U_{238+2d}	2.3E+03	2.0E–11	4.7E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		3.6E–06

Table H.V.2-68
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.106	kg/day
FI	Fraction ingested from contaminated source	0.5	(Unitless)
EF	Exposure frequency	350	days/year
EDn	Exposure duration for non-carcinogens	6	Year
EDc	Exposure duration for carcinogens	6	Year
BW	Body weight	15	kg
ATc	Average time for carcinogens (lifetime)	25550	days
ATn	Average time for non-carcinogens (EDn x365)	2190	days
CS	Concentration of chemicals in vegetables		

Chemical Concentrations

Compound	Concentration	Units
antimony	7.9E-01	mg/kg
arodor-1254	3.1E-04	mg/kg
arodor-1260		mg/kg
arsenic	2.3E-01	mg/kg
beryllium	6.6E-03	mg/kg
benzo(a)pyrene	2.3E-04	mg/kg
cadmium	3.3E-01	mg/kg
1,2-dichloroethane		mg/kg
magnesium	4.8E+03	mg/kg
manganese	2.0E+02	mg/kg
mercury	1.9E-01	mg/kg
silver	7.4E-01	mg/kg
2,3,7,8-tcdd		mg/kg
trichloroethene	1.2E-03	mg/kg
uranium-total	1.4E-01	mg/kg
		mg/kg

Compound	Concentration	Units
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg
		mg/kg

References

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Table H.V.2-68 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: On-Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.7E-03	4.0E-04	6.7E+00
aroclor-1254	1.1E-06	NA	NA
aroclor-1260	NA	NA	NA
arsenic	7.8E-04	3.0E-04	2.6E+00
beryllium	2.2E-05	5.0E-03	4.5E-03
benzo(a)pyrene	7.8E-07	NA	NA
cadmium	1.1E-03	1.0E-03	1.1E+00
1,2-dichloroethane	NA	NA	NA
magnesium	1.6E+01	9.7E+00	1.7E+00
manganese	6.9E-01	1.4E-01	4.9E+00
mercury	6.4E-04	3.0E-04	2.1E+00
silver	2.5E-03	5.0E-03	5.0E-01
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.1E-06	6.0E-03	6.8E-04
uranium-total	4.8E-04	3.0E-03	1.6E-01
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.0E+01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.3E-04	NA	NA
aroclor-1254	9.1E-08	7.7E+00	7.0E-07
aroclor-1260	NA	7.7E+00	NA
arsenic	6.7E-05	1.8E+00	1.2E-04
beryllium	1.9E-06	4.3E+00	8.3E-06
benzo(a)pyrene	6.7E-08	7.3E+00	4.9E-07
cadmium	9.5E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.4E+00	NA	NA
manganese	5.9E-02	NA	NA
mercury	5.5E-05	NA	NA
silver	2.1E-04	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.5E-07	1.1E-02	3.8E-09
uranium-total	4.1E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.3E-04

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Table H.V.2–69
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via Ingestion of Vegetables and Fruits

Risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.106 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	5.8E+00	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	3.0E+02	pCi/kg	pCi/kg
Tc_{99}	2.5E+03	pCi/kg	pCi/kg
Th_{230}	5.5E–01	pCi/kg	pCi/kg
$Th_{232+10d}$	2.7E–02	pCi/kg	pCi/kg
$U_{235/236}$	6.5E–01	pCi/kg	pCi/kg
U_{238+2d}	3.8E+01	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.4E+02	7.8E–10	5.0E–07
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	3.3E+04	3.6E–11	1.2E–06
Tc_{99}	2.8E+05	1.3E–12	3.6E–07
Th_{230}	6.1E+01	1.3E–11	7.9E–10
$Th_{232+10d}$	3.0E+00	1.7E–10	5.1E–10
$U_{235/236}$	7.2E+01	1.6E–11	1.2E–09
U_{238+2d}	4.3E+03	2.0E–11	8.5E–08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 2.1E–06

Table H.V.2–70
Summary of Risk Quantitation (radionuclides)
Reference Receptor: On–Property Farm Resident (Child)
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.96 (unitless)
ED	Exposure duration	6 Year
ET_i	Fraction of day spent indoors	0.92 (unitless)
ET_o	Fraction of day spent outdoors	0.08 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	3.84E–01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.19E–01	pCi/g	NA	pCi/g
Tc_{99}	2.50E–01	pCi/g	NA	pCi/g
Th_{230}	6.45E–01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.17E–02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.77E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.2E+00	6.0E–06	7.2E–06
Rn_{222}	NA	1.2E–09	NA
Sr_{90+1d}	3.7E–01	NA	
Tc_{99}	7.8E–01	6.0E–13	4.7E–13
Th_{230}	2.0E+00	5.4E–11	1.1E–10
$Th_{232+10d}$	9.9E–02	8.5E–06	8.4E–07
$U_{235/236}$	NA	2.4E–07	NA
U_{238+2d}	8.6E+00	5.1E–08	4.4E–07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 8.4E–06

Table H.V.2-71
Summary of risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Meat Products

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E-05	mg/kg			mg/kg
arodor-1254	7.5E-07	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	2.9E-05	mg/kg			mg/kg
beryllium	6.6E-07	mg/kg			mg/kg
benzo(a)pyrene	6.8E-07	mg/kg			mg/kg
cadmium	9.2E-06	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	1.2E+00	mg/kg			mg/kg
manganese	4.2E-03	mg/kg			mg/kg
mercury	2.4E-03	mg/kg			mg/kg
silver	1.1E-04	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	3.8E-10	mg/kg			mg/kg
uranium-total	2.2E-06	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-71 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.3E-08	4.0E-04	1.1E-04
aroclor-1254	7.7E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.0E-08	3.0E-04	9.8E-05
beryllium	6.8E-10	5.0E-03	1.4E-07
benzo(a)pyrene	7.0E-10	NA	NA
cadmium	9.4E-09	1.0E-03	9.4E-06
1,2-dichloroethane	NA	NA	NA
magnesium	1.2E-03	9.7E+00	1.3E-04
manganese	4.3E-06	1.4E-01	3.1E-05
mercury	2.4E-06	3.0E-04	8.1E-03
silver	1.2E-07	5.0E-03	2.3E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.9E-13	6.0E-03	6.5E-11
uranium-total	2.3E-09	3.0E-03	7.7E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		8.5E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	4.3E-08	NA	NA
aroclor-1254	7.7E-10	7.7E+00	5.9E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	3.0E-08	1.8E+00	5.2E-08
beryllium	6.8E-10	4.3E+00	2.9E-09
benzo(a)pyrene	7.0E-10	7.3E+00	5.1E-09
cadmium	9.4E-09	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.2E-03	NA	NA
manganese	4.3E-06	NA	NA
mercury	2.4E-06	NA	NA
silver	1.2E-07	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.9E-13	1.1E-02	4.3E-15
uranium-total	2.3E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.6E-08

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Table H.V.2–72
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Meat Products

risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.1 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	1.2E−04	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	4.5E−03	pCi/kg	pCi/kg
Tc_{99}	1.0E+00	pCi/kg	pCi/kg
Th_{230}	2.1E−06	pCi/kg	pCi/kg
$Th_{232+10d}$	1.0E−07	pCi/kg	pCi/kg
$U_{235/236}$	1.3E−06	pCi/kg	pCi/kg
U_{238+2d}	5.4E−04	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.2E−01	7.8E−10	1.7E−10
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	8.2E+00	3.6E−11	3.0E−10
Tc_{99}	1.9E+03	1.3E−12	2.4E−09
Th_{230}	3.9E−03	1.3E−11	5.0E−14
$Th_{232+10d}$	1.9E−04	1.7E−10	3.2E−14
$U_{235/236}$	2.4E−03	1.6E−11	3.9E−14
U_{238+2d}	1.0E+00	2.0E−11	2.0E−11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.9E−09

Table H.V.2–73
Summary of risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Dairy Products

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non–carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E–03	mg/kg			mg/kg
arodor–1254	2.4E–04	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	8.6E–04	mg/kg			mg/kg
beryllium	6.0E–07	mg/kg			mg/kg
benzo(a)pyrene	2.2E–04	mg/kg			mg/kg
cadmium	1.7E–02	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	9.6E+02	mg/kg			mg/kg
manganese	3.7E+00	mg/kg			mg/kg
mercury	4.3E–03	mg/kg			mg/kg
silver	7.5E–01	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	1.2E–07	mg/kg			mg/kg
uranium–total	6.8E–03	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-73 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.7E-05	4.0E-04	4.3E-02
aroclor-1254	9.7E-07	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.5E-06	3.0E-04	1.2E-02
beryllium	2.4E-09	5.0E-03	4.9E-07
benzo(a)pyrene	8.8E-07	NA	NA
cadmium	6.9E-05	1.0E-03	6.9E-02
1,2-dichloroethane	NA	NA	NA
magnesium	3.9E+00	9.7E+00	4.1E-01
manganese	1.5E-02	1.4E-01	1.1E-01
mercury	1.8E-05	3.0E-04	5.9E-02
silver	3.1E-03	5.0E-03	6.2E-01
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.9E-10	6.0E-03	8.2E-08
uranium-total	2.8E-05	3.0E-03	9.3E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.3E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.7E-05	NA	NA
aroclor-1254	9.7E-07	7.7E+00	7.5E-06
aroclor-1260	NA	7.7E+00	NA
arsenic	3.5E-06	1.8E+00	6.2E-06
beryllium	2.4E-09	4.3E+00	1.1E-08
benzo(a)pyrene	8.8E-07	7.3E+00	6.5E-06
cadmium	6.9E-05	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	3.9E+00	NA	NA
manganese	1.5E-02	NA	NA
mercury	1.8E-05	NA	NA
silver	3.1E-03	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.9E-10	1.1E-02	5.4E-12
uranium-total	2.8E-05	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		2.0E-05

000571

Table H.V.2–74
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Milk and Meat Consumer
Via Ingestion of Dairy Products

risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	2.2E−01	pCi/kg	pCi/kg
Rn_{222}	NA	pCi/kg	pCi/kg
Sr_{90+1d}	2.2E+01	pCi/kg	pCi/kg
Tc_{99}	1.2E+03	pCi/kg	pCi/kg
Th_{230}	1.7E−03	pCi/kg	pCi/kg
$Th_{232+10d}$	8.6E−05	pCi/kg	pCi/kg
$U_{235/236}$	4.8E−03	pCi/kg	pCi/kg
U_{238+2d}	1.6E+00	pCi/kg	pCi/kg
		pCi/kg	pCi/kg
		pCi/kg	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E+03	7.8E−10	1.2E−06
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	1.6E+05	3.6E−11	5.9E−06
Tc_{99}	8.8E+06	1.3E−12	1.1E−05
Th_{230}	1.3E+01	1.3E−11	1.7E−10
$Th_{232+10d}$	6.3E−01	1.7E−10	1.1E−10
$U_{235/236}$	3.5E+01	1.6E−11	5.6E−10
U_{238+2d}	1.2E+04	2.0E−11	2.4E−07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.9E−05

Table H.V.2-75
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	20 m^3/day
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non-carcinogens	25 Year
EDc	Exposure duration for carcinogens	25 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.0E-09	mg/m^3			mg/m^3
arodor-1254	1.6E-11	mg/m^3			mg/m^3
arodor-1260		mg/m^3			mg/m^3
arsenic	3.2E-09	mg/m^3			mg/m^3
beryllium	3.5E-10	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E-11	mg/m^3			mg/m^3
cadmium	3.0E-10	mg/m^3			mg/m^3
1,2-dichloroethane		mg/m^3			mg/m^3
magnesium	1.8E-06	mg/m^3			mg/m^3
manganese	4.5E-07	mg/m^3			mg/m^3
mercury	1.5E-10	mg/m^3			mg/m^3
silver	1.1E-09	mg/m^3			mg/m^3
2,3,7,8-tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E-13	mg/m^3			mg/m^3
uranium-total	1.1E-08	mg/m^3			mg/m^3
		mg/m^3			

References

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Table H.V.2-75 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.0E-10	NA	NA
aroclor-1254	3.1E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.2E-10	NA	NA
beryllium	6.8E-11	NA	NA
benzo(a)pyrene	2.2E-12	NA	NA
cadmium	5.9E-11	NA	NA
1,2-dichloroethane	NA	2.9E-03	NA
magnesium	3.6E-07	NA	NA
manganese	8.7E-08	1.4E-05	6.1E-03
mercury	2.9E-11	8.6E-05	3.4E-07
silver	2.2E-10	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	8.6E-14	NA	NA
uranium-total	2.1E-09	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	Hazard Quotient Sum =		6.1E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.4E-10	NA	NA
aroclor-1254	1.1E-12	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.2E-10	1.5E+01	3.3E-09
beryllium	2.4E-11	8.4E+00	2.0E-10
benzo(a)pyrene	7.8E-13	6.1E+00	4.7E-12
cadmium	2.1E-11	6.3E+00	1.3E-10
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.3E-07	NA	NA
manganese	3.1E-08	NA	NA
mercury	1.0E-11	NA	NA
silver	7.9E-11	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	3.1E-14	6.0E-03	1.9E-16
uranium-total	7.5E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.7E-09

000814

Table H.V.2–76
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Commercial/Industrial User
Via Inhalation of Gases and Particulates

Risk Equation = Ca X EF X EDn X IR

IR	Inhalation rate of gases (RAGS, 1989)		20 m^3/day
EF	Exposure frequency		250 days/year
EDn	Exposure duration		25 Year
Ca	Concentration of radionuclides in air		(see table below)

Ra_{226+8d}	1.4E−07	pCi/m^3	pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3	pCi/m^3
Sr_{90+1d}	4.8E−08	pCi/m^3	pCi/m^3
Tc_{99}	1.4E−07	pCi/m^3	pCi/m^3
Th_{230}	4.2E−07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	4.0E−09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.0E−06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.8E−02	7.0E−09	1.2E−10
Rn_{222}	2.3E+05	7.3E−13	1.7E−07
Sr_{90+1d}	6.0E−03	6.2E−11	3.7E−13
Tc_{99}	1.7E−02	8.3E−12	1.4E−13
Th_{230}	5.3E−02	2.9E−08	1.5E−09
$Th_{232+10d}$	5.0E−04	1.1E−07	5.5E−11
$U_{235/236}$	NA	2.5E−08	NA
U_{238+2d}	3.7E−01	2.4E−08	8.9E−09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.8E−07

Table H.V.2–77
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Incidental Ingestion of Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
CF	Conversion factor	1.0E–06 kg/mg
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non–carcinogens	25 Year
EDc	Exposure duration for carcinogens	25 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non–carcinogens (EDn x365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
arodor–1254	2.5E–02	mg/kg			mg/kg
arodor–1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E–01	mg/kg			mg/kg
benzo(a)pyrene	2.0E–02	mg/kg			mg/kg
cadmium	6.0E–01	mg/kg			mg/kg
1,2–dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E–01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8–tcdd		mg/kg			mg/kg
trichloroethene	7.6E–04	mg/kg			mg/kg
uranium–total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

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Table H.V.2-77 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Incidental Ingestion of Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.9E-06	4.0E-04	9.7E-03
aroclor-1254	2.4E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	5.6E-06	3.0E-04	1.9E-02
beryllium	6.5E-07	5.0E-03	1.3E-04
benzo(a)pyrene	2.0E-08	NA	NA
cadmium	5.8E-07	1.0E-03	5.8E-04
1,2-dichloroethane	NA	NA	NA
magnesium	4.6E-03	9.7E+00	4.8E-04
manganese	7.9E-04	1.4E-01	5.7E-03
mercury	2.0E-07	3.0E-04	6.8E-04
silver	1.8E-06	5.0E-03	3.6E-04
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.4E-10	6.0E-03	1.2E-07
uranium-total	1.1E-05	3.0E-03	3.8E-03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			4.0E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.4E-06	NA	
aroclor-1254	8.6E-09	7.7E+00	6.6E-08
aroclor-1260	NA	7.7E+00	NA
arsenic	2.0E-06	1.8E+00	3.5E-06
beryllium	2.3E-07	4.3E+00	9.9E-07
benzo(a)pyrene	7.0E-09	7.3E+00	5.1E-08
cadmium	2.1E-07	NA	
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.7E-03	NA	
manganese	2.8E-04	NA	
mercury	7.3E-08	NA	
silver	6.4E-07	NA	
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.6E-10	1.1E-02	2.9E-12
uranium-total	4.1E-06	NA	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			4.6E-06

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Table H.V.2-78
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Commercial/Industrial User
Via Incidental Ingestion of Soil

Risk Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	100 mg/day
EF	Exposure frequency	250 days/year
EDn	Exposure Duration	25 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	

Ra_{226+8d}	3.84E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.19E-04	pCi/mg	pCi/mg
Tc_{99}	2.50E-04	pCi/mg	pCi/mg
Th_{230}	6.45E-04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.17E-05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.77E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.40E+02	7.80E-10	1.87E-07
Rn_{222}	NA	1.40E-12	NA
Sr_{90+1d}	7.44E+01	3.60E-11	2.68E-09
Tc_{99}	1.56E+02	1.30E-12	2.03E-10
Th_{230}	4.03E+02	1.30E-11	5.24E-09
$Th_{232+10d}$	1.98E+01	1.70E-10	3.37E-09
$U_{235/236}$	NA	1.60E-11	NA
U_{238+2d}	1.73E+03	2.00E-11	3.46E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.33E-07

Table H.V.2-79
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Dermal Contact with Soil

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	5750 cm^2/day
AF	Soil to skin adherence factor (RAGS, 1989)	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E-06 kg/mg
EF	Exposure frequency	250 days/year
EDn	Exposure duration for non-carcinogens	25 Year
EDc	Exposure duration for carcinogens	25 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x365)	9125 days
CS	Concentration of chemicals in soil	

Chemical Concentrations

Compound	ABS	Concentrati	Units	Compound	Concentrati	Units
antimony	1.00E-02	3.97E+00	mg/kg		NA	mg/kg
arodor-1254	6.00E-02	2.46E-02	mg/kg		NA	mg/kg
arodor-1260	6.00E-02		mg/kg		NA	mg/kg
arsenic	1.00E-03	5.75E+00	mg/kg		NA	mg/kg
beryllium	1.00E-02	6.62E-01	mg/kg		NA	mg/kg
benzo(a)pyrene	3.00E-01	2.00E-02	mg/kg		NA	mg/kg
cadmium	1.00E-02	5.96E-01	mg/kg		NA	mg/kg
1,2-dichloroethane	3.00E-01		mg/kg		NA	mg/kg
magnesium	1.00E-02	4.75E+03	mg/kg		NA	mg/kg
manganese	1.00E-02	8.12E+02	mg/kg		NA	mg/kg
mercury	5.00E-02	2.09E-01	mg/kg		NA	mg/kg
silver	1.00E-02	1.84E+00	mg/kg		NA	mg/kg
2,3,7,8-tcdd	3.00E-02		mg/kg		NA	mg/kg
trichloroethene	3.00E-01	7.55E-04	mg/kg		NA	mg/kg
uranium-total	1.00E-02	1.16E+01	mg/kg		NA	mg/kg
	NA		mg/kg			

References

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Table H.V.2-79 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Commercial/Industrial User
Via Dermal Contact with Soil

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.23E-06	6.00E-05	3.72E-02
aroclor-1254	8.30E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.24E-07	2.85E-04	1.14E-03
beryllium	3.72E-07	5.00E-03	7.45E-05
benzo(a)pyrene	3.38E-07	NA	NA
cadmium	3.35E-07	5.00E-05	6.71E-03
1,2-dichloroethane	NA	NA	NA
magnesium	2.67E-03	4.85E-01	5.51E-03
manganese	4.57E-04	4.20E-03	1.09E-01
mercury	5.88E-07	4.50E-05	1.31E-02
silver	1.04E-06	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.27E-08	5.88E-03	2.17E-06
uranium-total	6.53E-06	1.50E-04	4.35E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		2.16E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	7.98E-07	NA	
aroclor-1254	2.97E-08	1.03E+01	3.04E-07
aroclor-1260	NA	1.03E+01	NA
arsenic	1.16E-07	1.84E+00	2.13E-07
beryllium	1.33E-07	4.30E+00	5.72E-07
benzo(a)pyrene	1.21E-07	NA	
cadmium	1.20E-07	NA	
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	9.54E-04	NA	
manganese	1.63E-04	NA	
mercury	2.10E-07	NA	
silver	3.70E-07	NA	
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	4.55E-09	1.12E-02	5.11E-11
uranium-total	2.33E-06	NA	
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.09E-06

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Table H.V.2-80
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Commercial/Industrial User
Via External Radiation

Dose Equivalency Equat: = $[DR \times EF \times EDn \times ET_i \times (1-SH_i)] + [DR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.68 (unitless)
ED	Exposure duration	25 Year
ET_i	Fraction of day spent indoors	0.8 (unitless)
ET_o	Fraction of day spent outdoors	0.2 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	(unitless)
DR	Radionuclide specific dose concentrations	(see table below)

Ra_{226+8d}	3.84E-01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.19E-01	pCi/g	NA	pCi/g
Tc_{99}	2.50E-01	pCi/g	NA	pCi/g
Th_{230}	6.45E-01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.17E-02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.77E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.9E+00	6.0E-06	2.4E-05
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	1.2E+00	NA	
Tc_{99}	2.6E+00	6.0E-13	1.5E-12
Th_{230}	6.6E+00	5.4E-11	3.6E-10
$Th_{232+10d}$	3.2E-01	8.5E-06	2.7E-06
$U_{235/236}$	NA	2.4E-07	NA
U_{238+2d}	2.8E+01	5.1E-08	1.4E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation		=	2.8E-05

Table H.V.2-81
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ET	Exposure time	4	4	4	2	hour/day
EF	Exposure frequency	64	104	40	40	days/year
ED	Exposure duration	6	12	38	14	years
BWa	Body weight (adult)	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	days
ATa	Average time for non-carcinogens (adult)	2190	4380	13870	5110	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units
antimony	2.0E-09	mg/m^3
arodor-1254	1.6E-11	mg/m^3
arodor-1260		mg/m^3
arsenic	3.2E-09	mg/m^3
beryllium	3.5E-10	mg/m^3
benzo(a)pyrene	1.1E-11	mg/m^3
cadmium	3.0E-10	mg/m^3
1,2-dichloroethane		mg/m^3
magnesium	1.8E-06	mg/m^3
manganese	4.5E-07	mg/m^3
mercury	1.5E-10	mg/m^3
silver	1.1E-09	mg/m^3
2,3,7,8-tcdd		mg/m^3
trichloroethene	4.4E-13	mg/m^3
uranium-total	1.1E-08	mg/m^3
		mg/m^3

Compound	Concentration	Units
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3
		mg/m^3

References

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Table H.V.2-81 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.1E-11	NA	NA
aroclor-1254	1.6E-13	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.3E-11	NA	NA
beryllium	3.6E-12	NA	NA
benzo(a)pyrene	1.2E-13	NA	NA
cadmium	3.2E-12	NA	NA
1,2-dichloroethane	NA	2.9E-03	
magnesium	1.9E-08	NA	NA
manganese	4.7E-09	1.4E-05	3.3E-04
mercury	1.5E-12	8.6E-05	1.8E-08
silver	1.2E-11	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.6E-15	NA	NA
uranium-total	1.1E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.3E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.1E-11	NA	NA
aroclor-1254	1.6E-13	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.3E-11	1.5E+01	4.9E-10
beryllium	3.6E-12	8.4E+00	3.0E-11
benzo(a)pyrene	1.2E-13	6.1E+00	7.1E-13
cadmium	3.2E-12	6.3E+00	2.0E-11
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.9E-08	NA	NA
manganese	4.7E-09	NA	NA
mercury	1.5E-12	NA	NA
silver	1.2E-11	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	4.6E-15	6.0E-03	2.8E-17
uranium-total	1.1E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		5.5E-10

000823

Table H.V.2–82
Summary of Intake and Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via Inhalation of Gases and Particulates

Intake Equation = CA X EF X ED X IR X ET

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ED	Exposure duration	6	12	38	14	years
ET	Exposure time	4	4	4	2	hour/day
EF	Exposure frequency	64	104	40	40	days/year
CA	Concentration of radionuclides in air	csv	csv	csv	csv	

Ra_{226+8d}	1.4E–07	pCi/m^3		pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3		pCi/m^3
Sr_{90+1d}	4.8E–08	pCi/m^3		pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3		pCi/m^3
Th_{230}	4.2E–07	pCi/m^3		pCi/m^3
$Th_{232+10d}$	4.0E–09	pCi/m^3		pCi/m^3
$U_{235/236}$		pCi/m^3		pCi/m^3
U_{238+2d}	3.0E–06	pCi/m^3		pCi/m^3
		pCi/m^3		pCi/m^3
		pCi/m^3		pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E–03	7.0E–09	1.1E–11
Rn_{222}	2.1E+04	7.3E–13	1.5E–08
Sr_{90+1d}	5.5E–04	6.2E–11	3.4E–14
Tc_{99}	1.6E–03	8.3E–12	1.3E–14
Th_{230}	4.8E–03	2.9E–08	1.4E–10
$Th_{232+10d}$	4.6E–05	1.1E–07	5.0E–12
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	3.4E–02	2.4E–08	8.1E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.6E–08

Table H.V.2-83
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Incidental Ingestion of Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	50	25	25	13	mg/day
EF	Exposure frequency	64	104	40	40	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E-06	1E-06	1E-06	1E-06	kg/mg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non-carcinogens	2190	4380	13870	5110	day
BW	Body weight	15	43	70	70	kg
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
aroclor-1254	2.5E-02	mg/kg			mg/kg
aroclor-1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E-01	mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium	6.0E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E-01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	7.6E-04	mg/kg			mg/kg
uranium-total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

000825

Table H.V.2-83 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.1E-07	4.0E-04	1.0E-03
aroclor-1254	2.6E-09	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.0E-07	3.0E-04	2.0E-03
beryllium	6.9E-08	5.0E-03	1.4E-05
benzo(a)pyrene	2.1E-09	NA	NA
cadmium	6.2E-08	1.0E-03	6.2E-05
1,2-dichloroethane	NA	NA	NA
magnesium	4.9E-04	9.7E+00	5.1E-05
manganese	8.4E-05	1.4E-01	6.0E-04
mercury	2.2E-08	3.0E-04	7.2E-05
silver	1.9E-07	5.0E-03	3.8E-05
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	7.8E-11	6.0E-03	1.3E-08
uranium-total	1.2E-06	3.0E-03	4.0E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.3E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	4.1E-07	NA	NA
aroclor-1254	2.6E-09	7.7E+00	2.0E-08
aroclor-1260	NA	7.7E+00	NA
arsenic	6.0E-07	1.8E+00	1.0E-06
beryllium	6.9E-08	4.3E+00	3.0E-07
benzo(a)pyrene	2.1E-09	7.3E+00	1.5E-08
cadmium	6.2E-08	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	4.9E-04	NA	NA
manganese	8.4E-05	NA	NA
mercury	2.2E-08	NA	NA
silver	1.9E-07	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	7.8E-11	1.1E-02	8.6E-13
uranium-total	1.2E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.4E-06

928900

Table H.V.2–84
Summary of Intake and Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via Incidental Ingestion of Soil/Sediment

Intake Equation = CS X EF X ED X FI X IR

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	50	25	25	13	mg/day
EF	Exposure frequency	64	104	40	40	days/year
ED	Exposure duration	6	12	38	14	year
FI	Fractional Intake	1	1	1	1	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Ra_{226+8d}	3.8E−04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.2E−04	pCi/mg	pCi/mg
Tc_{99}	2.5E−04	pCi/mg	pCi/mg
Th_{230}	6.5E−04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.2E−05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.8E−03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.7E−05	7.8E−10	2.9E−14
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	1.1E−05	3.6E−11	4.1E−16
Tc_{99}	2.4E−05	1.3E−12	3.1E−17
Th_{230}	6.2E−05	1.3E−11	8.0E−16
$Th_{232+10d}$	3.0E−06	1.7E−10	5.2E−16
$U_{235/236}$	NA	1.6E−11	NA
U_{238+2d}	2.7E−04	2.0E−11	5.3E−15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		3.6E−14

000827

Table H.V.2–85
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact with Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		child	youth	adult	senoir adult
SA	Surface area of exposed skin	2000	4138	5750	5750 cm^2/day
AF	Absorbtion factor	csv	csv	csv	csv (unitless)
EF	Exposure frequency	64	104	40	40 days/year
ED	Exposure duration	6	12	38	14 year
CF	Conversion factor	1E–06	1.000E–06	1E–06	1E–06 kg/mg
BW	Body weight	15	43	70	70 kg
AT	Average time for carcinogens	25550	25550	25550	25550 day
AT	Average time for non–carcinogens	2190	4380	13870	5110 day
ABS	Absorbtion factor	csv	csv	csv	csv (unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv

Chemical Concentrations

Compound	ABS	Concentration	Units	Compound	ABS	Concentration	Units
antimony	1.0E–02	4.0E+00	mg/kg		NA		mg/kg
arodor–1254	6.0E–02	2.5E–02	mg/kg		NA		mg/kg
arodor–1260	6.0E–02		mg/kg		NA		mg/kg
arsenic	1.0E–03	5.8E+00	mg/kg		NA		mg/kg
beryllium	1.0E–02	6.6E–01	mg/kg		NA		mg/kg
benzo(a)pyrene	3.0E–01	2.0E–02	mg/kg		NA		mg/kg
cadmium	1.0E–02	6.0E–01	mg/kg		NA		mg/kg
1,2–dichloroethane	3.0E–01		mg/kg		NA		mg/kg
magnesium	1.0E–02	4.8E+03	mg/kg		NA		mg/kg
manganese	1.0E–02	8.1E+02	mg/kg		NA		mg/kg
mercury	5.0E–02	2.1E–01	mg/kg		NA		mg/kg
silver	1.0E–02	1.8E+00	mg/kg		NA		mg/kg
2,3,7,8–todd	3.0E–02		mg/kg		NA		mg/kg
trichloroethene	3.0E–01	7.6E–04	mg/kg		NA		mg/kg
uranium–total	1.0E–02	1.2E+01	mg/kg		NA		mg/kg
	NA		mg/kg				

References

Table H.V.2-85 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.3E-07	6.0E-05	8.9E-03
aroclor-1254	2.0E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	7.7E-08	2.9E-04	2.7E-04
beryllium	8.9E-08	5.0E-03	1.8E-05
benzo(a)pyrene	8.0E-08	NA	NA
cadmium	8.0E-08	5.0E-05	1.6E-03
1,2-dichloroethane	NA	NA	NA
magnesium	6.4E-04	4.9E-01	1.3E-03
manganese	1.1E-04	4.2E-03	2.6E-02
mercury	1.4E-07	4.5E-05	3.1E-03
silver	2.5E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.0E-09	5.9E-03	5.2E-07
uranium-total	1.6E-06	1.5E-04	1.0E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.1E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.3E-07	NA	NA
aroclor-1254	2.0E-08	1.0E+01	2.0E-07
aroclor-1260	NA	1.0E+01	NA
arsenic	7.7E-08	1.8E+00	1.4E-07
beryllium	8.9E-08	4.3E+00	3.8E-07
benzo(a)pyrene	8.0E-08	NA	NA
cadmium	8.0E-08	NA	NA
1,2-dichloroethane	NA	1.0E-01	NA
magnesium	6.4E-04	NA	NA
manganese	1.1E-04	NA	NA
mercury	1.4E-07	NA	NA
silver	2.5E-07	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
trichloroethene	3.0E-09	1.1E-02	3.4E-11
uranium-total	1.6E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		7.3E-07

000839

Table H.V.2-86
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Ingestion While Wading

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non-carcinogens	2190	4380	13870	5110	days
CS	Concentration of chemicals in surface water	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E-04	mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	1.14E-03	mg/l			mg/l
beryllium	2.38E-05	mg/l			mg/l
benzo(a)pyrene	1.29E-08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	1.92E+01	mg/l			mg/l
manganese	1.42E-01	mg/l			mg/l
mercury	1.01E-03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	5.04E-04	mg/l			mg/l
		mg/l			

References

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Table H.V.2-86 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Ingestion While Wading

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.07E-09	4.00E-04	5.17E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.27E-08	3.00E-04	7.55E-05
beryllium	4.73E-10	5.00E-03	9.46E-08
benzo(a)pyrene	2.56E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	3.82E-04	9.70E+00	3.93E-05
manganese	2.82E-06	5.00E-03	5.65E-04
mercury	2.01E-08	3.00E-04	6.69E-05
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	1.00E-08	3.00E-03	3.34E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		7.55E-04

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.17E-08

Table H.V.2–87
Summary of Intake Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact While Wading

Intake Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
SA	Skin surface area		5130			cm^2
DA	chemicals specific dermal absorbed dose	csv	csv	csv	csv	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E–09	mg/cm^2–day			mg/cm^2–day
arodor–1254		mg/cm^2–day			mg/cm^2–day
arodor–1260		mg/cm^2–day			mg/cm^2–day
arsenic	1.14E–08	mg/cm^2–day			mg/cm^2–day
beryllium	2.38E–10	mg/cm^2–day			mg/cm^2–day
benzo(a)pyrene	7.29E–10	mg/cm^2–day			mg/cm^2–day
cadmium		mg/cm^2–day			mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day			mg/cm^2–day
magnesium	1.92E–04	mg/cm^2–day			mg/cm^2–day
manganese	1.42E–06	mg/cm^2–day			mg/cm^2–day
mercury	1.01E–08	mg/cm^2–day			mg/cm^2–day
silver		mg/cm^2–day			mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day			mg/cm^2–day
trichloroethene		mg/cm^2–day			mg/cm^2–day
uranium–total	5.04E–09	mg/cm^2–day			mg/cm^2–day
		mg/cm^2–day			

References

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Table H.V.2–87 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Developed Park User
Via Dermal Contact While Wading

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	3.03E–09	6.00E–05	5.05E–05
aroclor–1254	NA	NA	NA
aroclor–1260	NA	NA	NA
arsenic	3.32E–08	2.85E–04	1.17E–04
beryllium	6.93E–10	5.00E–03	1.39E–07
benzo(a)pyrene	2.12E–09	NA	NA
cadmium	NA	5.00E–05	NA
1,2–dichloroethane	NA	NA	NA
magnesium	5.59E–04	4.85E–01	1.15E–03
manganese	4.14E–06	4.20E–03	9.85E–04
mercury	2.94E–08	4.50E–05	6.54E–04
silver	NA	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	NA	5.88E–03	NA
uranium–total	1.47E–08	1.50E–04	9.79E–05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.06E–03

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	3.03E–09	NA	NA
aroclor–1254	NA	1.03E+01	NA
aroclor–1260	NA	1.03E+01	NA
arsenic	3.32E–08	1.84E+00	6.12E–08
beryllium	6.93E–10	4.30E+00	2.98E–09
benzo(a)pyrene	2.12E–09	NA	NA
cadmium	NA	NA	NA
1,2–dichloroethane	NA	1.01E–01	NA
magnesium	5.59E–04	NA	NA
manganese	4.14E–06	NA	NA
mercury	2.94E–08	NA	NA
silver	NA	NA	NA
2,3,7,8–tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E–02	NA
uranium–total	1.47E–08	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.42E–08

000633

Table H.V.2-88
Summary of Intake and Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via Incidental Ingestion while Wading

Intake Equation = CS X EF X ED X IRsw

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
Cs	Concentration of radionuclides in surface water	csv	csv	csv	csv	

Ra_{226+8d}	1.5E-03	pCi/l		pCi/l
Rn_{222}		pCi/l		pCi/l
Sr_{90+1d}	1.1E+00	pCi/l		pCi/l
Tc_{99}		pCi/l		pCi/l
Th_{230}	3.1E-03	pCi/l		pCi/l
$Th_{232+10d}$	1.7E-04	pCi/l		pCi/l
$U_{235/236}$	7.5E-03	pCi/l		pCi/l
U_{238+2d}	1.7E-01	pCi/l		pCi/l
		pCi/l		pCi/l
		pCi/l		pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.2E-02	7.8E-10	2.5E-11
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	2.4E+01	3.6E-11	8.6E-10
Tc_{99}	NA	1.3E-12	NA
Th_{230}	6.7E-02	1.3E-11	8.7E-13
$Th_{232+10d}$	3.6E-03	1.7E-10	6.2E-13
$U_{235/236}$	1.6E-01	1.6E-11	2.6E-12
U_{238+2d}	3.7E+00	2.0E-11	7.3E-11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		9.6E-10

Table H.V.2-89
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Developed Park User
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]+[CR \times EF \times ED \times ET_i \times (1-SH_i)]$

		child	youth	adult	senoir adult	
EF	Fraction of year spent exposured	0.18	0.28	0.11	0.11	(unitless)
ED	Exposure duration	6	12	38	14	years
ET_o	Fraction of day spent outdoors	0.17	0.17	0.17	0.08	(unitless)
ET_i	Fraction of day spent indoors	NA	NA	NA	NA	NA
SH_i	Shield factor indoors	0.5	0.5	0.5	0.5	(unitless)
SH_o	Shield factor outdoors					(unitless)
CR	Radionuclide specific concentrations	csv	csv	csv	csv	

Ra_{226+8d}	3.8E-01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.2E-01	pCi/g	NA	pCi/g
Tc_{99}	2.5E-01	pCi/g	NA	pCi/g
Th_{230}	6.5E-01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.2E-02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.8E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.1E-01	6.0E-06	3.7E-06
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	1.9E-01	NA	NA
Tc_{99}	4.0E-01	6.0E-13	2.4E-13
Th_{230}	1.0E+00	5.4E-11	5.5E-11
$Th_{232+10d}$	5.0E-02	8.5E-06	4.3E-07
$U_{235/236}$	NA	2.4E-07	NA
U_{238+2d}	4.4E+00	5.1E-08	2.2E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation		=	4.3E-06

Table H.V.2–90
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	26	39	52	26	days/year
ED	Exposure duration	6	12	38	14	years
BWa	Body weight (adult)	15	43	70	70	kg
AT	Average time for carcinogens	25550	25550	25550	25550	days
ATa	Average time for non–carcinogens (adult)	2190	4380	13870	5110	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.0E–09	mg/m^3			mg/m^3
arodor–1254	1.6E–11	mg/m^3			mg/m^3
arodor–1260		mg/m^3			mg/m^3
arsenic	3.2E–09	mg/m^3			mg/m^3
beryllium	3.5E–10	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E–11	mg/m^3			mg/m^3
cadmium	3.0E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	1.8E–06	mg/m^3			mg/m^3
manganese	4.5E–07	mg/m^3			mg/m^3
mercury	1.5E–10	mg/m^3			mg/m^3
silver	1.1E–09	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E–13	mg/m^3			mg/m^3
uranium–total	1.1E–08	mg/m^3			mg/m^3
		mg/m^3			

References

000836

6349

Table H.V.2-90 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	6.2E-12	NA	NA
aroclor-1254	4.8E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.6E-12	NA	NA
beryllium	1.1E-12	NA	NA
benzo(a)pyrene	3.4E-14	NA	NA
cadmium	9.2E-13	NA	NA
1,2-dichloroethane	NA	2.9E-03	
magnesium	5.6E-09	NA	NA
manganese	1.4E-09	1.4E-05	9.5E-05
mercury	4.5E-13	8.6E-05	5.3E-09
silver	3.4E-12	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	1.3E-15	NA	NA
uranium-total	3.3E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		9.5E-05

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.2E-12	NA	NA
aroclor-1254	4.8E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.6E-12	1.5E+01	1.4E-10
beryllium	1.1E-12	8.4E+00	8.9E-12
benzo(a)pyrene	3.4E-14	6.1E+00	2.1E-13
cadmium	9.2E-13	6.3E+00	5.8E-12
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	5.6E-09	NA	NA
manganese	1.4E-09	NA	NA
mercury	4.5E-13	NA	NA
silver	3.4E-12	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.3E-15	6.0E-03	8.1E-18
uranium-total	3.3E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.6E-10

008557

Table H.V.2–91
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via Inhalation of Gases and Particulates

Risk Equation = CA X EF X ED X IR X ET

		child	youth	adult	senoir adult	
IR	Inhalation rate of gases	0.83	0.83	0.83	0.83	m^3/hour
ED	Exposure duration	6	12	38	14	years
ET	Exposure time	1	2	2	1	hour/day
EF	Exposure frequency	26	39	52	26	days/year
CA	Concentration of radionuclides in air	csv	csv	csv	csv	

Ra_{226+8d}	1.4E–07	pCi/m^3	pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3	pCi/m^3
Sr_{90+1d}	4.8E–08	pCi/m^3	pCi/m^3
Tc_{99}	1.4E–07	pCi/m^3	pCi/m^3
Th_{230}	4.2E–07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	4.0E–09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.0E–06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	6.4E–04	7.0E–09	4.5E–12
Rn_{222}	8.3E+03	7.3E–13	6.0E–09
Sr_{90+1d}	2.2E–04	6.2E–11	1.3E–14
Tc_{99}	6.2E–04	8.3E–12	5.1E–15
Th_{230}	1.9E–03	2.9E–08	5.5E–11
$Th_{232+10d}$	1.8E–05	1.1E–07	2.0E–12
$U_{235/236}$	NA	2.5E–08	NA
U_{238+2d}	1.3E–02	2.4E–08	3.2E–10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 6.4E–09

Table H.V.2-92
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion of Soil/Sediment

Risk Equation $= \frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	26	39	52	26	days/year
ED	Exposure duration	6	12	38	14	year
CF	Conversion factor	1E-06	1E-06	1E-06	1E-06	kg/mg
AT	Average time for carcinogens	25550	25550	25550	25550	day
AT	Average time for non-carcinogens	2190	4380	13870	5110	day
BW	Body weight	15	43	70	70	kg
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
aroclor-1254	2.5E-02	mg/kg			mg/kg
aroclor-1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E-01	mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium	6.0E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E-01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	7.6E-04	mg/kg			mg/kg
uranium-total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

000839

Table H.V.2-92 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.0E-07	4.0E-04	2.6E-04
aroclor-1254	6.4E-10	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.5E-07	3.0E-04	5.0E-04
beryllium	1.7E-08	5.0E-03	3.4E-06
benzo(a)pyrene	5.2E-10	NA	NA
cadmium	1.5E-08	1.0E-03	1.5E-05
1,2-dichloroethane	NA	NA	NA
magnesium	1.2E-04	9.7E+00	1.3E-05
manganese	2.1E-05	1.4E-01	1.5E-04
mercury	5.4E-09	3.0E-04	1.8E-05
silver	4.8E-08	5.0E-03	9.6E-06
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	2.0E-11	6.0E-03	3.3E-09
uranium-total	3.0E-07	3.0E-03	1.0E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.1E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	1.0E-07	NA	NA
aroclor-1254	6.4E-10	7.7E+00	4.9E-09
aroclor-1260	NA	7.7E+00	NA
arsenic	1.5E-07	1.8E+00	2.6E-07
beryllium	1.7E-08	4.3E+00	7.4E-08
benzo(a)pyrene	5.2E-10	7.3E+00	3.8E-09
cadmium	1.5E-08	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.2E-04	NA	NA
manganese	2.1E-05	NA	NA
mercury	5.4E-09	NA	NA
silver	4.8E-08	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	2.0E-11	1.1E-02	2.2E-13
uranium-total	3.0E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.4E-07

008540

Table H.V.2–93
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion of Soil/Sediment

Risk Equation = CS X EF X ED X FI X IR

		child	youth	adult	senoir adult	
IR	Ingestion rate of soil	12	13	13	6	mg/day
EF	Exposure frequency	26	39	52	26	days/year
ED	Exposure duration	6	12	38	14	year
FI	Fractional Intake	1	1	1	1	(unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv	

Ra_{226+8d}	3.8E−04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.2E−04	pCi/mg	pCi/mg
Tc_{99}	2.5E−04	pCi/mg	pCi/mg
Th_{230}	6.5E−04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.2E−05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.8E−03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.4E−05	7.8E−10	1.1E−14
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	4.3E−06	3.6E−11	1.5E−16
Tc_{99}	9.0E−06	1.3E−12	1.2E−17
Th_{230}	2.3E−05	1.3E−11	3.0E−16
$Th_{232+10d}$	1.1E−06	1.7E−10	1.9E−16
$U_{235/236}$	NA	1.6E−11	NA
U_{238+2d}	9.9E−05	2.0E−11	2.0E−15
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.3E−14

Table H.V.2–94
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact with Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		child	youth	adult	senoir adult
SA	Surface area of exposed skin	2000	4138	5750	5750 cm^2/day
AF	Absorbtion factor	csv	csv	csv	csv (unitless)
EF	Exposure frequency	26	39	52	26 days/year
ED	Exposure duration	6	12	38	14 year
CF	Conversion factor	1E–06	1.000E–06	1E–06	1E–06 kg/mg
BW	Body weight	15	43	70	70 kg
AT	Average time for carcinogens	25550	25550	25550	25550 day
AT	Average time for non–carcinogens	2190	4380	13870	5110 day
ABS	Absorbtion factor	csv	csv	csv	csv (unitless)
CS	Concentration of chemicals in soil	csv	csv	csv	csv

Chemical Concentrations

Compound	ABS	Concentration	Units
antimony	1.0E–02	4.0E+00	mg/kg
arodor–1254	6.0E–02	2.5E–02	mg/kg
arodor–1260	6.0E–02		mg/kg
arsenic	1.0E–03	5.8E+00	mg/kg
beryllium	1.0E–02	6.6E–01	mg/kg
benzo(a)pyrene	3.0E–01	2.0E–02	mg/kg
cadmium	1.0E–02	6.0E–01	mg/kg
1,2–dichloroethane	3.0E–01		mg/kg
magnesium	1.0E–02	4.8E+03	mg/kg
manganese	1.0E–02	8.1E+02	mg/kg
mercury	5.0E–02	2.1E–01	mg/kg
silver	1.0E–02	1.8E+00	mg/kg
2,3,7,8–tcdd	3.0E–02		mg/kg
trichloroethene	3.0E–01	7.6E–04	mg/kg
uranium–total	1.0E–02	1.2E+01	mg/kg
	NA		mg/kg

Compound	ABS	Concentration	Units
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg

References

008842

Table H.V.2–94 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	4.0E–07	6.0E–05	6.7E–03
aroclor–1254	1.5E–08	NA	NA
aroclor–1260	NA	NA	NA
arsenic	5.8E–08	2.9E–04	2.0E–04
beryllium	6.7E–08	5.0E–03	1.3E–05
benzo(a)pyrene	6.1E–08	NA	NA
cadmium	6.0E–08	5.0E–05	1.2E–03
1,2–dichloroethane	NA	NA	NA
magnesium	4.8E–04	4.9E–01	9.9E–04
manganese	8.2E–05	4.2E–03	2.0E–02
mercury	1.1E–07	4.5E–05	2.3E–03
silver	1.9E–07	NA	NA
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	2.3E–09	5.9E–03	3.9E–07
uranium–total	1.2E–06	1.5E–04	7.8E–03
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.9E–02

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	4.0E–07	NA	NA
aroclor–1254	1.5E–08	1.0E+01	1.5E–07
aroclor–1260	NA	1.0E+01	NA
arsenic	5.8E–08	1.8E+00	1.1E–07
beryllium	6.7E–08	4.3E+00	2.9E–07
benzo(a)pyrene	6.1E–08	NA	NA
cadmium	6.0E–08	NA	NA
1,2–dichloroethane	NA	1.0E–01	NA
magnesium	4.8E–04	NA	NA
manganese	8.2E–05	NA	NA
mercury	1.1E–07	NA	NA
silver	1.9E–07	NA	NA
2,3,7,8–tcdd	NA	3.0E+05	NA
trichloroethene	2.3E–09	1.1E–02	2.6E–11
uranium–total	1.2E–06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		5.5E–07

008243

Table H.V.2-95
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Ingestion While Wading

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non-carcinogens	2190	4380	13870	5110	days
CS	Concentration of chemicals in surface water	csv	csv	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	1.04E-04	mg/l			mg/l
arodor-1254		mg/l			mg/l
arodor-1260		mg/l			mg/l
arsenic	1.14E-03	mg/l			mg/l
beryllium	2.38E-05	mg/l			mg/l
benzo(a)pyrene	1.29E-08	mg/l			mg/l
cadmium		mg/l			mg/l
1,2-dichloroethane		mg/l			mg/l
magnesium	1.92E+01	mg/l			mg/l
manganese	1.42E-01	mg/l			mg/l
mercury	1.01E-03	mg/l			mg/l
silver		mg/l			mg/l
2,3,7,8-tcdd		mg/l			mg/l
trichloroethene		mg/l			mg/l
uranium-total	5.04E-04	mg/l			mg/l
		mg/l			

References

Table H.V.2-95 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.07E-09	4.00E-04	5.17E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.27E-08	3.00E-04	7.55E-05
beryllium	4.73E-10	5.00E-03	9.46E-08
benzo(a)pyrene	2.56E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	3.82E-04	9.70E+00	3.93E-05
manganese	2.82E-06	5.00E-03	5.65E-04
mercury	2.01E-08	3.00E-04	6.69E-05
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	1.00E-08	3.00E-03	3.34E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		7.55E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.17E-08

008543

Table H.V.2–96
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact While Wading

Risk Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		child	youth	adult	senoir adult	
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
BW	Body weight		43			kg
AT	Average time for carcinogens		25550			days
AT	Average time for non–carcinogens	2190	4380	13870	5110	days
SA	Skin surface area		5130			cm^2
DA	chemicals specific dermal absorbed dose	csv	csv	csv	csv	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E–09	mg/cm^2–day			mg/cm^2–day
arodor–1254		mg/cm^2–day			mg/cm^2–day
arodor–1260		mg/cm^2–day			mg/cm^2–day
arsenic	1.14E–08	mg/cm^2–day			mg/cm^2–day
beryllium	2.38E–10	mg/cm^2–day			mg/cm^2–day
benzo(a)pyrene	7.29E–10	mg/cm^2–day			mg/cm^2–day
cadmium		mg/cm^2–day			mg/cm^2–day
1,2–dichloroethane		mg/cm^2–day			mg/cm^2–day
magnesium	1.92E–04	mg/cm^2–day			mg/cm^2–day
manganese	1.42E–06	mg/cm^2–day			mg/cm^2–day
mercury	1.01E–08	mg/cm^2–day			mg/cm^2–day
silver		mg/cm^2–day			mg/cm^2–day
2,3,7,8–tcdd		mg/cm^2–day			mg/cm^2–day
trichloroethene		mg/cm^2–day			mg/cm^2–day
uranium–total	5.04E–09	mg/cm^2–day			mg/cm^2–day
		mg/cm^2–day			

References

000843

6349

Table H.V.2-96 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Wildlife Reserve User
Via Dermal Contact While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.03E-09	6.00E-05	5.05E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.32E-08	2.85E-04	1.17E-04
beryllium	6.93E-10	5.00E-03	1.39E-07
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	5.59E-04	4.85E-01	1.15E-03
manganese	4.14E-06	4.20E-03	9.85E-04
mercury	2.94E-08	4.50E-05	6.54E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	1.47E-08	1.50E-04	9.79E-05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.06E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	5.59E-04	NA	NA
manganese	4.14E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	1.47E-08	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.42E-08

008247

Table H.V.2-97
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via Incidental Ingestion while Wading

Risk Equation = CS X EF X ED X IRsw

		child	youth	adult	senoir adult	
IRsw	Ingestion rate of surface water		0.035			l/day
EF	Exposure frequency		52			days/year
ED	Exposure duration		12			years
Cs	Concentration of radionuclides in surface water	csv	csv	csv	csv	

Ra_{226+8d}	1.5E-03	pCi/l		pCi/l
Rn_{222}		pCi/l		pCi/l
Sr_{90+1d}	1.1E+00	pCi/l		pCi/l
Tc_{99}		pCi/l		pCi/l
Th_{230}	3.1E-03	pCi/l		pCi/l
$Th_{232+10d}$	1.7E-04	pCi/l		pCi/l
$U_{235/236}$	7.5E-03	pCi/l		pCi/l
U_{238+2d}	1.7E-01	pCi/l		pCi/l
		pCi/l		pCi/l
		pCi/l		pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.2E-02	7.8E-10	2.5E-11
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	2.4E+01	3.6E-11	8.6E-10
Tc_{99}	NA	1.3E-12	NA
Th_{230}	6.7E-02	1.3E-11	8.7E-13
$Th_{232+10d}$	3.6E-03	1.7E-10	6.2E-13
$U_{235/236}$	1.6E-01	1.6E-11	2.6E-12
U_{238+2d}	3.7E+00	2.0E-11	7.3E-11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		9.6E-10

Table H.V.2-98
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Wildlife Reserve User
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]+[CR \times EF \times ED \times ET_i \times (1-SH_i)]$

		child	youth	adult	senoir adult	
EF	Fraction of year spent exposured	0.07	0.11	0.14	0.07	(unitless)
ED	Exposure duration	6	12	38	14	years
ET_o	Fraction of day spent outdoors	0.04	0.08	0.08	0.04	(unitless)
ET_i	Fraction of day spent indoors	NA	NA	NA	NA	NA
SH_i	Shield factor indoors	0.5	0.5	0.5	0.5	(unitless)
SH_o	Shield factor outdoors					(unitless)
CR	Radionuclide specific concentrations	csv	csv	csv	csv	

Ra_{226+8d}	3.8E-01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.2E-01	pCi/g	NA	pCi/g
Tc_{99}	2.5E-01	pCi/g	NA	pCi/g
Th_{230}	6.5E-01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.2E-02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.8E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	2.3E-01	6.0E-06	1.4E-06
Rn_{222}	NA	1.2E-09	NA
Sr_{90+1d}	7.0E-02	NA	NA
Tc_{99}	1.5E-01	6.0E-13	8.8E-14
Th_{230}	3.8E-01	5.4E-11	2.0E-11
$Th_{232+10d}$	1.9E-02	8.5E-06	1.6E-07
$U_{235/236}$	NA	2.4E-07	NA
U_{238+2d}	1.6E+00	5.1E-08	8.3E-08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		1.6E-06

Table H.V.2–99
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Inhalation of Particulates

Risk Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

		youth	adult	
IR	Inhalation rate of gases	0.83	0.83	m^3/hour
ETa	Exposure time (adult)	2	1	hour/day
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure duration (adult)	12	32	Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non–carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in particulate as modeled	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	2.0E–09	mg/m^3			mg/m^3
aroclor–1254	1.6E–11	mg/m^3			mg/m^3
aroclor–1260		mg/m^3			mg/m^3
arsenic	3.2E–09	mg/m^3			mg/m^3
beryllium	3.5E–10	mg/m^3			mg/m^3
benzo(a)pyrene	1.1E–11	mg/m^3			mg/m^3
cadmium	3.0E–10	mg/m^3			mg/m^3
1,2–dichloroethane		mg/m^3			mg/m^3
magnesium	1.8E–06	mg/m^3			mg/m^3
manganese	4.5E–07	mg/m^3			mg/m^3
mercury	1.5E–10	mg/m^3			mg/m^3
silver	1.1E–09	mg/m^3			mg/m^3
2,3,7,8–tcdd		mg/m^3			mg/m^3
trichloroethene	4.4E–13	mg/m^3			mg/m^3
uranium–total	1.1E–08	mg/m^3			mg/m^3
		mg/m^3			

References

005850

Table H.V.2-99 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Inhalation of Particulates

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.0E-12	NA	NA
aroclor-1254	1.5E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.1E-12	NA	NA
beryllium	3.4E-13	NA	NA
benzo(a)pyrene	1.1E-14	NA	NA
cadmium	2.9E-13	NA	NA
1,2-dichloroethane	NA	2.9E-03	
magnesium	1.8E-09	NA	NA
manganese	4.3E-10	1.4E-05	3.0E-05
mercury	1.4E-13	8.6E-05	1.7E-09
silver	1.1E-12	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	4.3E-16	NA	NA
uranium-total	1.0E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		3.0E-05

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	5.2E-12	NA	NA
aroclor-1254	4.1E-14	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.2E-12	1.5E+01	1.2E-10
beryllium	9.0E-13	8.4E+00	7.5E-12
benzo(a)pyrene	2.9E-14	6.1E+00	1.8E-13
cadmium	7.8E-13	6.3E+00	4.9E-12
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	4.8E-09	NA	NA
manganese	1.2E-09	NA	NA
mercury	3.8E-13	NA	NA
silver	2.9E-12	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	1.1E-15	6.0E-03	6.9E-18
uranium-total	2.8E-11	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		1.4E-10

0005654

Table H.V.2–100
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via Inhalation of Gases and Particulates

Risk Equation = CA X EF X ED X IR X ET

		youth	adult
IR	Inhalation rate of gases	0.83	0.83 m^3/hour
EFa	Exposure frequency (adult)	110	40 days/year
EDa	Exposure duration	12	32 Year
ETa	Exposure time (adult)	2	1 hour/day
CA	Concentration of radionuclides in air	csv	csv (see table below)

Ra_{226+8d}	1.4E−07	pCi/m^3	pCi/m^3
Rn_{222}	1.8E+00	pCi/m^3	pCi/m^3
Sr_{90+1d}	4.8E−08	pCi/m^3	pCi/m^3
Tc_{99}	1.4E−07	pCi/m^3	pCi/m^3
Th_{230}	4.2E−07	pCi/m^3	pCi/m^3
$Th_{232+10d}$	4.0E−09	pCi/m^3	pCi/m^3
$U_{235/236}$		pCi/m^3	pCi/m^3
U_{238+2d}	3.0E−06	pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3
		pCi/m^3	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	4.6E−04	7.0E−09	3.2E−12
Rn_{222}	6.0E+03	7.3E−13	4.4E−09
Sr_{90+1d}	1.6E−04	6.2E−11	9.7E−15
Tc_{99}	4.5E−04	8.3E−12	3.7E−15
Th_{230}	1.4E−03	2.9E−08	4.0E−11
$Th_{232+10d}$	1.3E−05	1.1E−07	1.4E−12
$U_{235/236}$	NA	2.5E−08	NA
U_{238+2d}	9.6E−03	2.4E−08	2.3E−10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		4.6E−09

Table H.V.2-101
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

		youth	adult	
IRa	Ingestion rate of soil (adult)	12.5	12.5	mg/day
CF	Conversion factor	1.00E-06	1.00E-06	kg/mg
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure duration (adult)	12	32	Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in soil	csv	csv	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.0E+00	mg/kg			mg/kg
arodor-1254	2.5E-02	mg/kg			mg/kg
arodor-1260		mg/kg			mg/kg
arsenic	5.8E+00	mg/kg			mg/kg
beryllium	6.6E-01	mg/kg			mg/kg
benzo(a)pyrene	2.0E-02	mg/kg			mg/kg
cadmium	6.0E-01	mg/kg			mg/kg
1,2-dichloroethane		mg/kg			mg/kg
magnesium	4.8E+03	mg/kg			mg/kg
manganese	8.1E+02	mg/kg			mg/kg
mercury	2.1E-01	mg/kg			mg/kg
silver	1.8E+00	mg/kg			mg/kg
2,3,7,8-tcdd		mg/kg			mg/kg
trichloroethene	7.6E-04	mg/kg			mg/kg
uranium-total	1.2E+01	mg/kg			mg/kg
		mg/kg			

References

000853

Table H.V.2–101 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg–day)	RfD (mg/kg–day)	HQ (unitless)
antimony	1.5E–07	4.0E–04	3.8E–04
aroclor–1254	9.4E–10	NA	NA
aroclor–1260	NA	NA	NA
arsenic	2.2E–07	3.0E–04	7.3E–04
beryllium	2.5E–08	5.0E–03	5.0E–06
benzo(a)pyrene	7.6E–10	NA	NA
cadmium	2.3E–08	1.0E–03	2.3E–05
1,2–dichloroethane	NA	NA	NA
magnesium	1.8E–04	9.7E+00	1.9E–05
manganese	3.1E–05	1.4E–01	2.2E–04
mercury	8.0E–09	3.0E–04	2.7E–05
silver	7.0E–08	5.0E–03	1.4E–05
2,3,7,8–tcdd	NA	NA	NA
trichloroethene	2.9E–11	6.0E–03	4.8E–09
uranium–total	4.4E–07	3.0E–03	1.5E–04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.6E–03

	ILCR Calculation		
Compound	CDI (mg/kg–day)	CSF $(mg/kg–day)^{-1}$	ILCR (unitless)
antimony	9.5E–08	NA	NA
aroclor–1254	5.9E–10	7.7E+00	4.5E–09
aroclor–1260	NA	7.7E+00	NA
arsenic	1.4E–07	1.8E+00	2.4E–07
beryllium	1.6E–08	4.3E+00	6.8E–08
benzo(a)pyrene	4.8E–10	7.3E+00	3.5E–09
cadmium	1.4E–08	NA	NA
1,2–dichloroethane	NA	9.1E–02	NA
magnesium	1.1E–04	NA	NA
manganese	1.9E–05	NA	NA
mercury	5.0E–09	NA	NA
silver	4.4E–08	NA	NA
2,3,7,8–tcdd	NA	1.5E+05	NA
trichloroethene	1.8E–11	1.1E–02	2.0E–13
uranium–total	2.8E–07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		3.2E–07

000034

Table H.V.2-102
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion of Soil/Sediment

Risk Equation = CS X EF X ED X FI X IR

		youth	adult	
IRa	Ingestion rate of soil (adult)	12.5	12.5	mg/day
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure Duration	12	32	Year
FI	Fractional Intake	1	1	(unitless)
CS	Concentration of radionuclides in soil	csv	csv	

Ra_{226+8d}	3.8E-04	pCi/mg	pCi/mg
Rn_{222}		pCi/mg	pCi/mg
Sr_{90+1d}	1.2E-04	pCi/mg	pCi/mg
Tc_{99}	2.5E-04	pCi/mg	pCi/mg
Th_{230}	6.5E-04	pCi/mg	pCi/mg
$Th_{232+10d}$	3.2E-05	pCi/mg	pCi/mg
$U_{235/236}$		pCi/mg	pCi/mg
U_{238+2d}	2.8E-03	pCi/mg	pCi/mg
		pCi/mg	pCi/mg
		pCi/mg	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.2E+01	7.8E-10	9.7E-09
Rn_{222}	NA	1.4E-12	NA
Sr_{90+1d}	3.9E+00	3.6E-11	1.4E-10
Tc_{99}	8.1E+00	1.3E-12	1.1E-11
Th_{230}	2.1E+01	1.3E-11	2.7E-10
$Th_{232+10d}$	1.0E+00	1.7E-10	1.8E-10
$U_{235/236}$	NA	1.6E-11	NA
U_{238+2d}	9.0E+01	2.0E-11	1.8E-09
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 1.2E-08

Table H.V.2-103
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact with Soil/Sediment

Risk Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

		youth	adult	
SA	Surface area of exposed skin (adult)	4200	5750	cm^2/day
AF	Soil to skin adherence factor	1	1	mg/cm^2
ABS	chemicals specific absorbtion factor	csv	csv	
CF	Conversion factor	1.0E-06	1.0E-06	kg/mg
EFa	Exposure frequency (adult)	110	40	days/year
EDa	Exposure duration (adult)	12	32	Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in soil	csv	csv	

Chemical Concentrations

Compound	ABS	Concentration	Units
antimony	1.0E-02	4.0E+00	mg/kg
arodor-1254	6.0E-02	2.5E-02	mg/kg
arodor-1260	6.0E-02		mg/kg
arsenic	1.0E-03	5.8E+00	mg/kg
beryllium	1.0E-02	6.6E-01	mg/kg
benzo(a)pyrene	3.0E-01	2.0E-02	mg/kg
cadmium	1.0E-02	6.0E-01	mg/kg
1,2-dichloroethane	3.0E-01		mg/kg
magnesium	1.0E-02	4.8E+03	mg/kg
manganese	1.0E-02	8.1E+02	mg/kg
mercury	5.0E-02	2.1E-01	mg/kg
silver	1.0E-02	1.8E+00	mg/kg
2,3,7,8-tcdd	3.0E-02		mg/kg
trichloroethene	3.0E-01	7.6E-04	mg/kg
uranium-total	1.0E-02	1.2E+01	mg/kg
	NA		mg/kg

Compound	ABS	Concentration	Units
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg
	NA		mg/kg

References

958000

Table H.V.2-103 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact with Soil/Sediment

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	5.8E-07	6.0E-05	9.6E-03
aroclor-1254	2.2E-08	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.4E-08	2.9E-04	2.9E-04
beryllium	9.6E-08	5.0E-03	1.9E-05
benzo(a)pyrene	8.7E-08	NA	NA
cadmium	8.7E-08	5.0E-05	1.7E-03
1,2-dichloroethane	NA	NA	NA
magnesium	6.9E-04	4.9E-01	1.4E-03
manganese	1.2E-04	4.2E-03	2.8E-02
mercury	1.5E-07	4.5E-05	3.4E-03
silver	2.7E-07	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	3.3E-09	5.9E-03	5.6E-07
uranium-total	1.7E-06	1.5E-04	1.1E-02
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		5.6E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.6E-07	NA	NA
aroclor-1254	1.4E-08	1.0E+01	1.4E-07
aroclor-1260	NA	1.0E+01	NA
arsenic	5.3E-08	1.8E+00	9.7E-08
beryllium	6.1E-08	4.3E+00	2.6E-07
benzo(a)pyrene	5.5E-08	NA	NA
cadmium	5.5E-08	NA	NA
1,2-dichloroethane	NA	1.0E-01	NA
magnesium	4.4E-04	NA	NA
manganese	7.4E-05	NA	NA
mercury	9.6E-08	NA	NA
silver	1.7E-07	NA	NA
2,3,7,8-tcdd	NA	3.0E+05	NA
trichloroethene	2.1E-09	1.1E-02	2.3E-11
uranium-total	1.1E-06	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		5.0E-07

458000

Table H.V.2-104
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Ingestion While Wading

Risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

		youth	adult	
IRsw	Ingestion rate of surface water	0.035		l/day
EFa	Exposure frequency (adult)	52		days/year
EDa	Exposure duration (adult)	12		Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
CS	Concentration of chemicals in surface water	csv	csv	

Chemical Concentrations

Compound	Concentration	Units
antimony	1.04E-04	mg/l
arodor-1254		mg/l
arodor-1260		mg/l
arsenic	1.14E-03	mg/l
beryllium	2.38E-05	mg/l
benzo(a)pyrene	1.29E-08	mg/l
cadmium		mg/l
1,2-dichloroethane		mg/l
magnesium	1.92E+01	mg/l
manganese	1.42E-01	mg/l
mercury	1.01E-03	mg/l
silver		mg/l
2,3,7,8-tcdd		mg/l
trichloroethene		mg/l
uranium-total	5.04E-04	mg/l
		mg/l

Compound	Concentration	Units
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l
		mg/l

References

000578

Table H.V.2-104
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.29E-09	4.00E-04	8.22E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.61E-08	3.00E-04	1.20E-04
beryllium	7.53E-10	5.00E-03	1.51E-07
benzo(a)pyrene	4.08E-13	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	6.07E-04	9.70E+00	6.26E-05
manganese	4.49E-06	5.00E-03	8.98E-04
mercury	3.19E-08	3.00E-04	1.06E-04
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	1.59E-08	3.00E-03	5.31E-06
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		1.20E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.07E-09	NA	NA
aroclor-1254		7.70E+00	NA
aroclor-1260		7.70E+00	NA
arsenic	2.27E-08	1.75E+00	3.97E-08
beryllium	4.73E-10	4.30E+00	2.03E-09
benzo(a)pyrene	2.56E-13	7.30E+00	1.87E-12
cadmium	NA	NA	NA
1,2-dichloroethane		9.10E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	NA	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd		1.50E+05	NA
trichloroethene		1.10E-02	NA
uranium-total	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		4.17E-08

000859

Table H.V.2-105
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact While Wading

Risk Equation = $\frac{EF \times ED \times DA \times SA}{BW \times AT}$

		youth	adult	
EFa	Exposure frequency (adult)	52		days/year
EDa	Exposure duration (adult)	12		Year
BWa	Body weight (adult)	43	70	kg
AT	Average time for carcinogens	25550	25550	days
ATa	Average time for non-carcinogens (adult)	4380	11680	days
DA	chemicals specific dermal absorbed dose	csv	csv	
SAa	Skin surface area (adult)	5130		cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	1.04E-09	mg/cm^2-day			mg/cm^2-day
aroclor-1254		mg/cm^2-day			mg/cm^2-day
aroclor-1260		mg/cm^2-day			mg/cm^2-day
arsenic	1.14E-08	mg/cm^2-day			mg/cm^2-day
beryllium	2.38E-10	mg/cm^2-day			mg/cm^2-day
benzo(a)pyrene	7.29E-10	mg/cm^2-day			mg/cm^2-day
cadmium		mg/cm^2-day			mg/cm^2-day
1,2-dichloroethane		mg/cm^2-day			mg/cm^2-day
magnesium	1.92E-04	mg/cm^2-day			mg/cm^2-day
manganese	1.42E-06	mg/cm^2-day			mg/cm^2-day
mercury	1.01E-08	mg/cm^2-day			mg/cm^2-day
silver		mg/cm^2-day			mg/cm^2-day
2,3,7,8-tcdd		mg/cm^2-day			mg/cm^2-day
trichloroethene		mg/cm^2-day			mg/cm^2-day
uranium-total	5.04E-09	mg/cm^2-day			mg/cm^2-day
		mg/cm^2-day			

References

038000

6349

Table H.V.2-105 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Expanded Trespasser
Via Dermal Contact While Wading

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.82E-09	6.00E-05	8.03E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	5.28E-08	2.85E-04	1.85E-04
beryllium	1.10E-09	5.00E-03	2.21E-07
benzo(a)pyrene	3.38E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	8.90E-04	4.85E-01	1.84E-03
manganese	6.58E-06	4.20E-03	1.57E-03
mercury	4.68E-08	4.50E-05	1.04E-03
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	2.34E-08	1.50E-04	1.56E-04
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.86E-03

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.03E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	3.32E-08	1.84E+00	6.12E-08
beryllium	6.93E-10	4.30E+00	2.98E-09
benzo(a)pyrene	2.12E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	5.59E-04	NA	NA
manganese	4.14E-06	NA	NA
mercury	2.94E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	1.47E-08	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.42E-08

000861

Table H.V.2–106
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via Incidental Ingestion while Wading

Risk Equation = CS X EF X ED X FI X IRsw

		youth	adult	
IRsw	Ingestion rate of surface water	0.035		l/day
EFa	Exposure frequency (adult)	52		days/year
EDa	Exposure duration (adult)	12		Year
FI	Fractional intake for radionuclides	1		1 (Unitless)
Cs	Concentration of radionuclides in surface water	csv	csv	

Ra_{226+8d}	1.5E–03	pCi/l	pCi/l
Rn_{222}		pCi/l	pCi/l
Sr_{90+1d}	1.1E+00	pCi/l	pCi/l
Tc_{99}		pCi/l	pCi/l
Th_{230}	3.1E–03	pCi/l	pCi/l
$Th_{232+10d}$	1.7E–04	pCi/l	pCi/l
$U_{235/236}$	7.5E–03	pCi/l	pCi/l
U_{238+2d}	1.7E–01	pCi/l	pCi/l
		pCi/l	pCi/l
		pCi/l	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.2E–02	7.8E–10	2.5E–11
Rn_{222}	NA	1.4E–12	NA
Sr_{90+1d}	2.4E+01	3.6E–11	8.6E–10
Tc_{99}	NA	1.3E–12	NA
Th_{230}	6.7E–02	1.3E–11	8.7E–13
$Th_{232+10d}$	3.6E–03	1.7E–10	6.2E–13
$U_{235/236}$	1.6E–01	1.6E–11	2.6E–12
U_{238+2d}	3.7E+00	2.0E–11	7.3E–11
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA

ILCR Summation = 9.6E–10

Table H.V.2–107
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Expanded Trespasser
Via External Radiation

Exposure Equation = $[CR \times EF \times ED \times ET_o \times (1-SH_o)]$

		youth	adult	
EFa	Fraction of year spent exposured (adult)	0.3	0.11	(unitless)
EDa	Exposure duration (adult)	12	32	Year
ET_∞	Fraction of day spent outdoors (adult)	0.08	0.04	(unitless)
SH_o	Shield factor outdoors			(unitless)
CR	Radionuclide specific concentrations	csv	csv	(see table below)

Ra_{226+8d}	3.8E−01	pCi/g	NA	pCi/g
Rn_{222}	NA	pCi/g	NA	pCi/g
Sr_{90+1d}	1.2E−01	pCi/g	NA	pCi/g
Tc_{99}	2.5E−01	pCi/g	NA	pCi/g
Th_{230}	6.5E−01	pCi/g	NA	pCi/g
$Th_{232+10d}$	3.2E−02	pCi/g	NA	pCi/g
$U_{235/236}$	NA	pCi/g	NA	pCi/g
U_{238+2d}	2.8E+00	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g
	NA	pCi/g	NA	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.6E−01	6.0E−06	9.9E−07
Rn_{222}	NA	1.2E−09	NA
Sr_{90+1d}	5.1E−02	NA	NA
Tc_{99}	1.1E−01	6.0E−13	6.4E−14
Th_{230}	2.8E−01	5.4E−11	1.5E−11
$Th_{232+10d}$	1.4E−02	8.5E−06	1.2E−07
$U_{235/236}$	NA	2.4E−07	NA
U_{238+2d}	1.2E+00	5.1E−08	6.1E−08
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation		=	1.2E−06

Table H.V.2-108
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Meat Products

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E-10	mg/kg	NA	NA	mg/kg
aroclor-1254	NA	mg/kg	NA	NA	mg/kg
aroclor-1260	NA	mg/kg	NA	NA	mg/kg
arsenic	8.7E-09	mg/kg	NA	NA	mg/kg
beryllium	9.4E-11	mg/kg	NA	NA	mg/kg
benzo(a)pyrene	1.1E-11	mg/kg	NA	NA	mg/kg
cadmium	NA	mg/kg	NA	NA	mg/kg
1,2-dichloroethane	NA	mg/kg	NA	NA	mg/kg
magnesium	1.1E-03	mg/kg	NA	NA	mg/kg
manganese	2.3E-07	mg/kg	NA	NA	mg/kg
mercury	1.0E-06	mg/kg	NA	NA	mg/kg
silver	NA	mg/kg	NA	NA	mg/kg
2,3,7,8-tcdd	NA	mg/kg	NA	NA	mg/kg
trichloroethene	NA	mg/kg	NA	NA	mg/kg
uranium-total	4.5E-10	mg/kg	NA	NA	mg/kg
NA	NA	mg/kg			

References

Table H.V.2-108 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Meat Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	4.4E-13	4.0E-04	1.1E-09
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.0E-12	3.0E-04	3.0E-08
beryllium	9.7E-14	5.0E-03	1.9E-11
benzo(a)pyrene	1.2E-14	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	1.1E-06	9.7E+00	1.1E-07
manganese	2.4E-10	1.4E-01	1.7E-09
mercury	1.1E-09	3.0E-04	3.5E-06
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	4.6E-13	3.0E-03	1.5E-10
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			3.7E-06

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	4.4E-13	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	9.0E-12	1.8E+00	1.6E-11
beryllium	9.7E-14	4.3E+00	4.2E-13
benzo(a)pyrene	1.2E-14	7.3E+00	8.4E-14
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.1E-06	NA	NA
manganese	2.4E-10	NA	NA
mercury	1.1E-09	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	4.6E-13	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			1.6E-11

000855

Table H.V.2-109
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Meat Products

risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.101 kg/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	9.2E−10	pCi/kg	NA	NA	pCi/kg
Rn_{222}	ERR	pCi/kg	NA	NA	pCi/kg
Sr_{90+1d}	1.1E−06	pCi/kg	NA	NA	pCi/kg
Tc_{99}	9.5E−04	pCi/kg	NA	NA	pCi/kg
Th_{230}	3.7E−10	pCi/kg	NA	NA	pCi/kg
$Th_{232+10d}$	2.5E−12	pCi/kg	NA	NA	pCi/kg
$U_{235/236}$	6.6E−09	pCi/kg	NA	NA	pCi/kg
U_{238+2d}	1.5E−07	pCi/kg	NA	NA	pCi/kg
NA	NA	pCi/kg	NA	NA	pCi/kg
NA	NA	pCi/kg	NA	NA	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.7E−06	7.8E−10	1.3E−15
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	2.1E−03	3.6E−11	7.4E−14
Tc_{99}	1.8E+00	1.3E−12	2.3E−12
Th_{230}	6.8E−07	1.3E−11	8.9E−18
$Th_{232+10d}$	4.7E−09	1.7E−10	8.0E−19
$U_{235/236}$	1.2E−05	1.6E−11	2.0E−16
U_{238+2d}	2.8E−04	2.0E−11	5.5E−15
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
ILCR Summation	=		2.4E−12

Table H.V.2-110
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Dairy Products

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	5.1E-08	mg/kg	NA	NA	mg/kg
aroclor-1254	NA	mg/kg	NA	NA	mg/kg
aroclor-1260	NA	mg/kg	NA	NA	mg/kg
arsenic	3.1E-07	mg/kg	NA	NA	mg/kg
beryllium	1.0E-10	mg/kg	NA	NA	mg/kg
benzo(a)pyrene	4.2E-09	mg/kg	NA	NA	mg/kg
cadmium	NA	mg/kg	NA	NA	mg/kg
1,2-dichloroethane	NA	mg/kg	NA	NA	mg/kg
magnesium	1.0E+00	mg/kg	NA	NA	mg/kg
manganese	2.4E-04	mg/kg	NA	NA	mg/kg
mercury	2.2E-06	mg/kg	NA	NA	mg/kg
silver	NA	mg/kg	NA	NA	mg/kg
2,3,7,8-tcdd	NA	mg/kg	NA	NA	mg/kg
trichloroethene	NA	mg/kg	NA	NA	mg/kg
uranium-total	1.6E-06	mg/kg	NA	NA	mg/kg
NA	NA	mg/kg			

References

000827

Table H.V.2-110 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Dairy Products

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.1E-10	4.0E-04	5.2E-07
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.3E-09	3.0E-04	4.3E-06
beryllium	4.1E-13	5.0E-03	8.3E-11
benzo(a)pyrene	1.7E-11	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	4.2E-03	9.7E+00	4.3E-04
manganese	9.9E-07	1.4E-01	7.1E-06
mercury	9.1E-09	3.0E-04	3.0E-05
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	6.6E-09	3.0E-03	2.2E-06
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
HQ Summation =			4.7E-04

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.1E-10	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	1.3E-09	1.8E+00	2.3E-09
beryllium	4.1E-13	4.3E+00	1.8E-12
benzo(a)pyrene	1.7E-11	7.3E+00	1.3E-10
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	4.2E-03	NA	NA
manganese	9.9E-07	NA	NA
mercury	9.1E-09	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	6.6E-09	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
ILCR Summation =			2.4E-09

0008988

Table H.V.2-111
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Dairy Products

risk Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.4 l/day
FI	Fraction ingested from contaminated source	0.75 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Ra_{226+8d}	2.0E−06	pCi/kg	NA	NA	pCi/kg
Rn_{222}	NA	pCi/kg	NA	NA	pCi/kg
Sr_{90+1d}	6.7E−03	pCi/kg	NA	NA	pCi/kg
Tc_{99}	1.3E+00	pCi/kg	NA	NA	pCi/kg
Th_{230}	3.7E−07	pCi/kg	NA	NA	pCi/kg
$Th_{232+10d}$	2.5E−09	pCi/kg	NA	NA	pCi/kg
$U_{235/236}$	2.4E−05	pCi/kg	NA	NA	pCi/kg
U_{238+2d}	5.4E−04	pCi/kg	NA	NA	pCi/kg
NA	NA	pCi/kg	NA	NA	pCi/kg
NA	NA	pCi/kg	NA	NA	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.5E−02	7.8E−10	1.1E−11
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	4.9E+01	3.6E−11	1.8E−09
Tc_{99}	9.8E+03	1.3E−12	1.3E−08
Th_{230}	2.7E−03	1.3E−11	3.5E−14
$Th_{232+10d}$	1.9E−05	1.7E−10	3.2E−15
$U_{235/236}$	1.7E−01	1.6E−11	2.8E−12
U_{238+2d}	3.9E+00	2.0E−11	7.9E−11
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
ILCR Summation	=		1.5E−08

Table H.V.2-112
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User
Via Ingestion of Vegetables and Fruits

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	4.2E-05	mg/kg	NA	ERR	mg/kg
aroclor-1254	NA	mg/kg	NA	ERR	mg/kg
aroclor-1260	NA	mg/kg	NA	ERR	mg/kg
arsenic	4.3E-04	mg/kg	NA	ERR	mg/kg
beryllium	9.2E-06	mg/kg	NA	ERR	mg/kg
benzo(a)pyrene	3.5E-08	mg/kg	NA	ERR	mg/kg
cadmium	NA	mg/kg	NA	ERR	mg/kg
1,2-dichloroethane	NA	mg/kg	NA	ERR	mg/kg
magnesium	2.1E+01	mg/kg	NA	ERR	mg/kg
manganese	5.6E-02	mg/kg	NA	ERR	mg/kg
mercury	4.0E-04	mg/kg	NA	ERR	mg/kg
silver	NA	mg/kg	NA	ERR	mg/kg
2,3,7,8-tcdd	NA	mg/kg	NA	ERR	mg/kg
trichloroethene	NA	mg/kg	NA	ERR	mg/kg
uranium-total	2.2E-04	mg/kg	NA	ERR	mg/kg
NA	ERR	mg/kg			

References

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Table H.V.2-112 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	3.5E-08	4.0E-04	8.7E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	3.6E-07	3.0E-04	1.2E-03
beryllium	7.6E-09	5.0E-03	1.5E-06
benzo(a)pyrene	2.9E-11	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	1.8E-02	9.7E+00	1.8E-03
manganese	4.7E-05	1.4E-01	3.4E-04
mercury	3.4E-07	3.0E-04	1.1E-03
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	1.8E-07	3.0E-03	6.1E-05
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	HQ Summation =		4.6E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	3.5E-08	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	3.6E-07	1.8E+00	6.2E-07
beryllium	7.6E-09	4.3E+00	3.3E-08
benzo(a)pyrene	2.9E-11	7.3E+00	2.1E-10
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	1.8E-02	NA	NA
manganese	4.7E-05	NA	NA
mercury	3.4E-07	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	1.8E-07	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	ILCR Summation =		6.6E-07

008274

Table H.V.2-113
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Agricultural)
Via Ingestion of Vegetables and Fruits

risk Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.122 kg/day
FI	Fraction ingested from contaminated source	0.5 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cv	Concentration of radionuclides in vegetables	

Ra_{226+8d}	3.6E−04	pCi/kg	NA	ERR	pCi/kg
Rn_{222}	ERR	pCi/kg	NA	ERR	pCi/kg
Sr_{90+1d}	3.7E−01	pCi/kg	NA	ERR	pCi/kg
Tc_{99}	1.1E+01	pCi/kg	NA	ERR	pCi/kg
Th_{230}	6.0E−03	pCi/kg	NA	ERR	pCi/kg
$Th_{232+10d}$	4.1E−05	pCi/kg	NA	ERR	pCi/kg
$U_{235/236}$	3.2E−03	pCi/kg	NA	ERR	pCi/kg
U_{238+2d}	7.3E−02	pCi/kg	NA	ERR	pCi/kg
NA	ERR	pCi/kg	NA	ERR	pCi/kg
NA	ERR	pCi/kg	NA	ERR	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	5.4E−01	7.8E−10	4.2E−10
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	5.5E+02	3.6E−11	2.0E−08
Tc_{99}	1.7E+04	1.3E−12	2.2E−08
Th_{230}	9.0E+00	1.3E−11	1.2E−10
$Th_{232+10d}$	6.2E−02	1.7E−10	1.0E−11
$U_{235/236}$	4.8E+00	1.6E−11	7.7E−11
U_{238+2d}	1.1E+02	2.0E−11	2.2E−09
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA

ILCR Summation = 4.5E−08

Table H.V.2-114

Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Residential)
Via Drinking Water Ingestion

risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	8.48E-06	mg/l	NA	NA	mg/l
aroclor-1254	NA	mg/l	NA	NA	mg/l
aroclor-1260	NA	mg/l	NA	NA	mg/l
arsenic	8.72E-05	mg/l	NA	NA	mg/l
beryllium	1.87E-06	mg/l	NA	NA	mg/l
benzo(a)pyrene	7.08E-09	mg/l	NA	NA	mg/l
cadmium	NA	mg/l	NA	NA	mg/l
1,2-dichloroethane	NA	mg/l	NA	NA	mg/l
magnesium	4.21E+00	mg/l	NA	NA	mg/l
manganese	1.15E-02	mg/l	NA	NA	mg/l
mercury	8.18E-05	mg/l	NA	NA	mg/l
silver	NA	mg/l	NA	NA	mg/l
2,3,7,8-tcdd	NA	mg/l	NA	NA	mg/l
trichloroethene	NA	mg/l	NA	NA	mg/l
uranium-total	4.47E-05	mg/l	NA	NA	mg/l
NA	NA	mg/l			

References

000673

Table H.V.2-114
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Residential)
Via Drinking Water Ingestion

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.32E-07	4.00E-04	5.81E-04
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	2.39E-06	3.00E-04	7.96E-03
beryllium	5.12E-08	5.00E-03	1.02E-05
benzo(a)pyrene	1.94E-10	NA	NA
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	1.15E-01	9.70E+00	1.19E-02
manganese	3.15E-04	1.40E-01	2.25E-03
mercury	2.24E-06	3.00E-04	7.47E-03
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	1.22E-06	3.00E-03	4.08E-04
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
	HQ Summation =		3.06E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	2.32E-07	NA	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	2.39E-06	1.75E+00	4.18E-06
beryllium	5.12E-08	4.30E+00	2.20E-07
benzo(a)pyrene	1.94E-10	7.30E+00	1.42E-09
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	1.15E-01	NA	NA
manganese	3.15E-04	NA	NA
mercury	2.24E-06	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	1.22E-06	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
	ILCR Summation =		4.40E-06

0008274

Table H.V.2-115
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Residential)
Via Ingestion of Drinking Water

risk Equation = Cw X EF X EDn X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2 l/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cw	Concentration of radionuclides in groundwater	(see table below)

Ra_{226+8d}	7.4E−05	pCi/l	NA	NA	pCi/l
Rn_{222}	NA	pCi/l	NA	NA	pCi/l
Sr_{90+1d}	7.4E−02	pCi/l	NA	NA	pCi/l
Tc_{99}	2.2E+00	pCi/l	NA	NA	pCi/l
Th_{230}	1.2E−03	pCi/l	NA	NA	pCi/l
$Th_{232+10d}$	8.4E−06	pCi/l	NA	NA	pCi/l
$U_{235/236}$	6.6E−04	pCi/l	NA	NA	pCi/l
U_{238+2d}	1.5E−02	pCi/l	NA	NA	pCi/l
NA	NA	pCi/l	NA	NA	pCi/l
NA	NA	pCi/l	NA	NA	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	3.6E+00	7.8E−10	2.8E−09
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	3.6E+03	3.6E−11	1.3E−07
Tc_{99}	1.1E+05	1.3E−12	1.4E−07
Th_{230}	6.0E+01	1.3E−11	7.8E−10
$Th_{232+10d}$	4.1E−01	1.7E−10	7.0E−11
$U_{235/236}$	3.2E+01	1.6E−11	5.2E−10
U_{238+2d}	7.3E+02	2.0E−11	1.5E−08
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA

ILCR Summation = 2.9E−07

Table H.V.2-116
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Residential)
Via Dermal Contact while Bathing

risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2-day
EF	Exposure frequency	350 days/year
EDn	Exposure duration for non-carcinogens	70 Year
EDc	Exposure duration for carcinogens	70 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	2.12E-11	mg/cm^2-day	NA	NA	mg/cm^2-day
aroclor-1254	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
aroclor-1260	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
arsenic	2.18E-10	mg/cm^2-day	NA	NA	mg/cm^2-day
beryllium	4.68E-12	mg/cm^2-day	NA	NA	mg/cm^2-day
benzo(a)pyrene	2.00E-10	mg/cm^2-day	NA	NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
1,2-dichloroethane	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
magnesium	1.05E-05	mg/cm^2-day	NA	NA	mg/cm^2-day
manganese	2.88E-08	mg/cm^2-day	NA	NA	mg/cm^2-day
mercury	2.05E-10	mg/cm^2-day	NA	NA	mg/cm^2-day
silver	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
2,3,7,8-tcdd	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
trichloroethene	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
uranium-total	1.12E-10	mg/cm^2-day	NA	NA	mg/cm^2-day
NA	NA	mg/cm^2-day			

References

9/8900

Table H.V.2-116 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	6.68E-09	6.00E-05	1.11E-04
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	6.87E-08	2.85E-04	2.41E-04
beryllium	1.47E-09	5.00E-03	2.95E-07
benzo(a)pyrene	6.30E-08	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	3.32E-03	4.85E-01	6.84E-03
manganese	9.06E-06	4.20E-03	2.16E-03
mercury	6.44E-08	4.50E-05	1.43E-03
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	3.52E-08	1.50E-04	2.35E-04
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
	HQ Summation =		1.10E-02

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	6.68E-09	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	6.87E-08	1.84E+00	1.27E-07
beryllium	1.47E-09	4.30E+00	6.33E-09
benzo(a)pyrene	6.30E-08	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	3.32E-03	NA	NA
manganese	9.06E-06	NA	NA
mercury	6.44E-08	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	3.52E-08	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
	ILCR Summation =		1.33E-07

000877

Table H.V.2-117
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Ingestion of Fish

risk Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of fish	0.054 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	122 days/year
EDn	Exposure duration for non-carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	10950 days
CS	Concentration of chemicals in meat	csv

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
antimony	8.5E-06	mg/kg	•••	NA	mg/kg
aroclor-1254	NA	mg/kg	•••	NA	mg/kg
aroclor-1260	NA	mg/kg	•••	NA	mg/kg
arsenic	3.8E-03	mg/kg	•••	NA	mg/kg
beryllium	3.6E-05	mg/kg	•••	NA	mg/kg
benzo(a)pyrene	1.8E-04	mg/kg	•••	NA	mg/kg
cadmium	NA	mg/kg	•••	NA	mg/kg
1,2-dichloroethane	NA	mg/kg	•••	NA	mg/kg
magnesium	0.0E+00	mg/kg	•••	NA	mg/kg
manganese	0.0E+00	mg/kg	•••	NA	mg/kg
mercury	4.5E-01	mg/kg	•••	NA	mg/kg
silver	NA	mg/kg	•••	NA	mg/kg
2,3,7,8-tcdd	NA	mg/kg	•••	NA	mg/kg
trichloroethene	NA	mg/kg	•••	NA	mg/kg
uranium-total	8.9E-08	mg/kg	•••	NA	mg/kg
0	NA	mg/kg			

References

82000

Table H.V.2-117 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Ingestion of Fish

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	2.2E-09	4.0E-04	5.5E-06
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	9.9E-07	3.0E-04	3.3E-03
beryllium	9.2E-09	5.0E-03	1.8E-06
benzo(a)pyrene	4.6E-08	NA	NA
cadmium	NA	1.0E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	NA	9.7E+00	NA
manganese	NA	1.4E-01	NA
mercury	1.2E-04	3.0E-04	3.9E-01
silver	NA	5.0E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.0E-03	NA
uranium-total	2.3E-11	3.0E-03	7.7E-09
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
0	NA	NA	NA
HQ Summation =			3.9E-01

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF (mg/kg-day)	ILCR (unitless)
antimony	9.4E-10	NA	NA
aroclor-1254	NA	7.7E+00	NA
aroclor-1260	NA	7.7E+00	NA
arsenic	4.2E-07	1.8E+00	7.4E-07
beryllium	3.9E-09	4.3E+00	1.7E-08
benzo(a)pyrene	2.0E-08	7.3E+00	1.5E-07
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.1E-02	NA
magnesium	NA	NA	NA
manganese	NA	NA	NA
mercury	5.0E-05	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.5E+05	NA
trichloroethene	NA	1.1E-02	NA
uranium-total	9.9E-12	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
0.0E+00	NA	NA	NA
ILCR Summation =			9.0E-07

678000

Table H.V.2-118;
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Recreational)
Via Ingestion of Fish

risk Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.054 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	122 days/year
EDn	Exposure duration	30 Year
Cf	Concentration of radionuclides in meat	

Ra_{226+8d}	3.7E−06	pCi/kg	NA	pCi/kg
Rn_{222}	NA	pCi/kg	NA	pCi/kg
Sr_{90+1d}	2.2E−03	pCi/kg	NA	pCi/kg
Tc_{99}	3.3E−02	pCi/kg	NA	pCi/kg
Th_{230}	3.7E−05	pCi/kg	NA	pCi/kg
$Th_{232+10d}$	2.5E−07	pCi/kg	NA	pCi/kg
$U_{235/236}$	1.3E−06	pCi/kg	NA	pCi/kg
U_{238+2d}	3.0E−05	pCi/kg	NA	pCi/kg
	NA	pCi/kg	NA	pCi/kg
	NA	pCi/kg	NA	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	1.8E−07	7.8E−10	1.4E−16
Rn_{222}	NA	1.4E−12	NA
Sr_{90+1d}	2.2E−04	3.6E−11	7.9E−15
Tc_{99}	1.9E−01	1.3E−12	2.4E−13
Th_{230}	7.3E−08	1.3E−11	9.5E−19
$Th_{232+10d}$	5.0E−10	1.7E−10	8.5E−20
$U_{235/236}$	1.3E−06	1.6E−11	2.1E−17
U_{238+2d}	2.9E−05	2.0E−11	5.9E−16
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation	=		2.5E−13

Table H.V.2-119

Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Incidental Ingestion While Wading

risk Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non-carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	10950 days
ATn	Average time for non-carcinogens (EDn x 365)	10950 days
CS	Concentration of chemicals in surface water	

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	8.48E-06	mg/cm^2-d	NA	NA	mg/cm^2-d
aroclor-1254	NA	mg/cm^2-d	NA	NA	mg/cm^2-d
aroclor-1260	NA	mg/cm^2-d	NA	NA	mg/cm^2-d
arsenic	8.72E-05	mg/cm^2-d	NA	NA	mg/cm^2-d
beryllium	1.87E-06	mg/cm^2-d	NA	NA	mg/cm^2-d
benzo(a)pyrene	7.08E-09	mg/cm^2-d	NA	NA	mg/cm^2-d
cadmium	NA	mg/cm^2-d	NA	NA	mg/cm^2-d
1,2-dichloroethane	NA	mg/cm^2-d	NA	NA	mg/cm^2-d
magnesium	4.21E+00	mg/cm^2-d	NA	NA	mg/cm^2-d
manganese	1.15E-02	mg/cm^2-d	NA	NA	mg/cm^2-d
mercury	8.18E-05	mg/cm^2-d	NA	NA	mg/cm^2-d
silver	NA	mg/cm^2-d	NA	NA	mg/cm^2-d
2,3,7,8-tcdd	NA	mg/cm^2-d	NA	NA	mg/cm^2-d
trichloroethene	NA	mg/cm^2-d	NA	NA	mg/cm^2-d
uranium-total	4.47E-05	mg/cm^2-d	NA	NA	mg/cm^2-d
NA	NA	mg/cm^2-d			

References

000884

Table H.V.2-119 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Incidental Ingestion While Wading

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	8.13E-11	4.00E-04	2.03E-07
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	8.36E-10	3.00E-04	2.79E-06
beryllium	1.79E-11	5.00E-03	3.59E-09
benzo(a)pyrene	6.79E-14	NA	ERR
cadmium	NA	1.00E-03	NA
1,2-dichloroethane	NA	NA	NA
magnesium	4.04E-05	9.70E+00	4.16E-06
manganese	1.10E-07	5.00E-03	2.21E-05
mercury	7.84E-10	3.00E-04	2.61E-06
silver	NA	5.00E-03	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	6.00E-03	NA
uranium-total	4.29E-10	3.00E-03	1.43E-07
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
HQ Summation =			ERR

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
antimony	8.13E-11	NA	NA
aroclor-1254	NA	7.70E+00	NA
aroclor-1260	NA	7.70E+00	NA
arsenic	8.36E-10	1.75E+00	1.46E-09
beryllium	1.79E-11	4.30E+00	7.71E-11
benzo(a)pyrene	6.79E-14	7.30E+00	4.96E-13
cadmium	NA	NA	NA
1,2-dichloroethane	NA	9.10E-02	NA
magnesium	4.04E-05	NA	NA
manganese	1.10E-07	NA	NA
mercury	7.84E-10	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	1.50E+05	NA
trichloroethene	NA	1.10E-02	NA
uranium-total	4.29E-10	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
	NA	NA	NA
ILCR Summation =			1.54E-09

000382

Table H.V.2-120
Summary of Risk Quantitation (radionuclides)
Reference Receptor: Great Miami River User (Recreational)
Via Incidental Ingestion while Wading

risk Equation = Cs X EF X ED X FI X IR

IRsw	Ingestion rate of surface water	0.035 l/day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non−carcinogens	30 Year
FI	Fractional intake for radionuclides	1 (Unitless)
Cs	Concentration of radionuclides in surface water	

Ra_{226+8d}	7.37E−05	pCi/l	NA	NA	pCi/l
Rn_{222}	NA	pCi/l	NA	NA	pCi/l
Sr_{90+1d}	7.43E−02	pCi/l	NA	NA	pCi/l
Tc_{99}	2.23E+00	pCi/l	NA	NA	pCi/l
Th_{230}	1.23E−03	pCi/l	NA	NA	pCi/l
$Th_{232+10d}$	8.44E−06	pCi/l	NA	NA	pCi/l
$U_{235/236}$	6.61E−04	pCi/l	NA	NA	pCi/l
U_{238+2d}	1.49E−02	pCi/l	NA	NA	pCi/l
NA	NA	pCi/l	NA	NA	pCi/l
NA	NA	pCi/l	NA	NA	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Ra_{226+8d}	5.42E−04	7.80E−10	4.23E−13
Rn_{222}	NA	1.40E−12	NA
Sr_{90+1d}	5.46E−01	3.60E−11	1.97E−11
Tc_{99}	1.64E+01	1.30E−12	2.13E−11
Th_{230}	9.04E−03	1.30E−11	1.18E−13
$Th_{232+10d}$	6.20E−05	1.70E−10	1.05E−14
$U_{235/236}$	4.86E−03	1.60E−11	7.77E−14
U_{238+2d}	1.10E−01	2.00E−11	2.19E−12
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
	ILCR Summation =		4.38E−11

Table H.V.2-121
Summary of risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Dermal Contact while Wading

risk Equation = $\frac{DA \times EF \times ED \times SA}{BW \times AT}$

DA	Dermal absorbed dose	csv mg/cm^2-day
EF	Exposure frequency	7 days/year
EDn	Exposure duration for non-carcinogens	30 Year
EDc	Exposure duration for carcinogens	30 Year
BW	Body weight	70 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	25550 days
SA	Skin surface area available for contact	23000 cm^2

Chemical Concentrations

Compound	DA	Units	Compound	DA	Units
antimony	2.12E-11	mg/cm^2-day	NA	NA	mg/cm^2-day
aroclor-1254	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
aroclor-1260	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
arsenic	2.18E-10	mg/cm^2-day	NA	NA	mg/cm^2-day
beryllium	4.68E-12	mg/cm^2-day	NA	NA	mg/cm^2-day
benzo(a)pyrene	2.00E-10	mg/cm^2-day	NA	NA	mg/cm^2-day
cadmium	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
1,2-dichloroethane	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
magnesium	1.05E-05	mg/cm^2-day	NA	NA	mg/cm^2-day
manganese	2.88E-08	mg/cm^2-day	NA	NA	mg/cm^2-day
mercury	2.05E-10	mg/cm^2-day	NA	NA	mg/cm^2-day
silver	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
2,3,7,8-tcdd	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
trichloroethene	NA	mg/cm^2-day	NA	NA	mg/cm^2-day
uranium-total	1.12E-10	mg/cm^2-day	NA	NA	mg/cm^2-day
NA	NA	mg/cm^2-day			

References

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Table H.V.2-121 (continued)
Summary of Risk Quantitation (chemicals)
Reference Receptor: Great Miami River User (Recreational)
Via Dermal Contact while Bathing

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
antimony	1.25E-09	6.00E-05	2.08E-05
aroclor-1254	NA	NA	NA
aroclor-1260	NA	NA	NA
arsenic	1.28E-08	2.85E-04	4.50E-05
beryllium	2.75E-10	5.00E-03	5.50E-08
benzo(a)pyrene	5.88E-09	NA	NA
cadmium	NA	5.00E-05	NA
1,2-dichloroethane	NA	NA	NA
magnesium	6.19E-04	4.85E-01	1.28E-03
manganese	1.69E-06	4.20E-03	4.03E-04
mercury	1.20E-08	4.50E-05	2.67E-04
silver	NA	NA	NA
2,3,7,8-tcdd	NA	NA	NA
trichloroethene	NA	5.88E-03	NA
uranium-total	6.57E-09	1.50E-04	4.38E-05
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
	HQ Summation =		2.06E-03

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF (mg/kg-day)	ILCR (unitless)
antimony	5.34E-10	NA	NA
aroclor-1254	NA	1.03E+01	NA
aroclor-1260	NA	1.03E+01	NA
arsenic	5.49E-09	1.84E+00	1.01E-08
beryllium	1.18E-10	4.30E+00	5.07E-10
benzo(a)pyrene	2.52E-09	NA	NA
cadmium	NA	NA	NA
1,2-dichloroethane	NA	1.01E-01	NA
magnesium	2.65E-04	NA	NA
manganese	7.25E-07	NA	NA
mercury	5.15E-09	NA	NA
silver	NA	NA	NA
2,3,7,8-tcdd	NA	3.00E+05	NA
trichloroethene	NA	1.12E-02	NA
uranium-total	2.82E-09	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
NA	NA	NA	NA
	ILCR Summation =		1.06E-08

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ATTACHMENT H.VI
QUANTITATIVE UNCERTAINTY ANALYSIS OF EXPOSURE PARAMETERS AND THE IMPACT ON PRELIMINARY REMEDIATION GOALS (PRGs)

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H.VI QUANTITATIVE UNCERTAINTY ANALYSIS OF EXPOSURE PARAMETERS AND THE IMPACT ON PRELIMINARY REMEDIATION GOALS (PRGs)

All environmental assessment models are inherently uncertain. Detailed models are usually limited due to the lack of data for model parameters. Simpler models require less information but are restricted by reducing complex systems to a few equations. Errors in model prediction therefore arise from several sources. These sources are categorized as improper parameter estimation (parameter bias), improper model formulation (model bias), and stochastic effects due to random measurement and sampling errors or random variability. As a result of these uncertainties the real phenomena referred to as compounded conservativism is often encountered. Compounded conservativism is described in a paper by Kenneth T. Bogen as the impact of using conservative, upper bound estimates of the values of multiple input variables in order to obtain a conservative estimate of risk. Bogen goes on to indicate that the amount of compounded conservativism depends on the number of inputs, their relative uncertainties, covariance, and the upper p-fractile value. In one case, for independent lognormally distributed parameters, the overestimation factor, when using the 95 percentile inputs, was found to be 5, 99.7, and 506,000 for the number of inputs of 2, 4, and 10 respectively (Bogen, 1994). What these results illustrate is that the amount of overestimation is related to the p-fractile used and the number of inputs at that p-fractile. Another study, which evaluated different measures of compounded conservativism, found that although there is unevenness in the relationship between the number of inputs and the corresponding overestimation factor there is behavior common to both (Cullen 1994). An additional finding was that the point estimates of risk using the 95 percentiles for the parameter inputs consistently fell above the 95 percentile of the simulated distribution. The results of these quantitative uncertainty analyses show that the incompleteness of knowledge about risk exposure are completely captured in a probabilistic assessment and there is no "uncertainty of uncertainty."

This section presents the assumptions, methodology, and results of the quantitative uncertainty analysis related to the PRG development based on risk assessment for the Operable Unit 5 Feasibility Study (FS). The objective of the uncertainty analysis associated with risk assessment is to clearly describe the uncertainties related to the process of estimating risks from exposures to environmental contaminants. It is important to recall that there are four distinct parts of a risk assessment. These are broadly characterized as the Source Term, Fate and Transport, Exposure Assessment, and the Toxicity Assessment. These four parts are combined to represent the risk associated with potential exposures to an individual from contaminants in the environment.

This attachment only addresses the uncertainties associated with exposure assessment parameters. This attachment is divided into five sections: 1) the introduction which discusses the overall considerations associated with propagation of error and uncertainty, 2) the approach and methodology

used for this uncertainty evaluation including the results of a sensitivity analysis , 3) the basic assumptions made for each exposure parameter, 4) the results of the uncertainty analysis, and 5) the conclusions and interpretations of the results.

H.VI.1 INTRODUCTION

The purpose of the quantitative uncertainty analysis is to present risk managers with additional information to base the risk management decisions upon. By presenting the PRGs as distributions and point estimates, the risk manager is provided information which describes the certainty with which the PRG is protective at the selected risk level. This is accomplished by establishing a comparability between the risk ranges, the probability distribution, and associated cleanup levels (often referred to as PRGs). The parameters used in constructing the point estimates are generally near the upper end of the distribution and therefore will tend to result in estimates that are at or above the 95th percentile (Bogen 1994 and Smith 1994). The ideal situation, for decision making purposes, is to have comparative point estimates that fall within the median and the 70 percentile or 90 percentile of any given distribution. A comparison of the PRGs calculated as a point estimate, at the 95 percentile or above, and the median provides an indication of the potential range of cleanup levels.

Assessment of the risk due to releases to the environment requires the use of mathematical models that can describe the transport and exposure of contaminants to humans (receptors). These models use values that quantify the relationships between considered media, including air, land, food, human tissues, and other model parameters. The results of the risk assessment are used by risk managers to assist in making decisions concerning the acceptability of risks under various scenarios.

This section summarizes the quantitative analysis of uncertainty associated with the overall risk model used to develop PRGs based only on bias in the exposure parameters. In this limited study no attempt was made to separate variability from uncertainty in the analysis of the exposure parameters. There is sufficient information concerning the exposure parameters to perform a stochastic or probabilistic evaluation. The limitations with this approach are briefly addressed in Section H.VI.5. The overall uncertainty associated with the estimation of risk for this CRARE has been presented and discussed in previous sections. This sections attempts to describe quantitatively the impact of the uncertainty, related to exposure parameters, on the development of preliminary remediation goals (PRGs, see Section 2 of the FS). The details of this analysis including the assumptions, methodology, and results are provided in Section H.5. This section presents a summary of the major findings and the critical results on the PRGs.

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H.VI.2 APPROACH AND METHODOLOGY

The approach used for this evaluation is a straight forward and standard method that has been applied in numerous cases of modeling and risk assessments (reference 1). The overall approach uses what is referred to as Monte Carlo Simulation as the basis for developing the distributions of the probability curves. Monte Carlo analysis is simply described as a random sampling process given a known (or assumed) probability distribution. Using this technique and many random simulations cumulative probability distributions, can be developed based on any number of parameters.

Scenarios investigated for this quantitative evaluation of uncertainty include the resident farmer, the industrial worker (groundskeeper), and a developed park user. The overall approach to the quantitative uncertainty analysis will address only the exposure assessment portion of the overall risk characterization. The overall risk estimate is based on four specific stages of the analysis which are linear multipliers. These four stages are: (1) source term development, (2) nature and extent of contamination, (3) exposure assessment, and (4) the toxicity assessment. The exposure assessment portion, addressed here only deals with those exposure factors related to exposure duration and frequency or standard human physiology, but does not include factors related to physiological parameters associated with uptake and bioavailability.

The reason for limiting this study to the exposure portion of PRG development is that many of the exposure parameters have sufficient data to characterize the shape and distribution for the parameter. Many of these parameters have "standard" distributions developed by other independent organizations such as the American Industrial Health Council. The majority of the standard distributions used in this study are unlikely to be significantly influenced by site-specific conditions.

Some exposure factors do not have standard or "known" distributions. These factors are still candidates for the uncertainty analysis. Monte Carlo analysis can be performed where factors can only be specified in terms of relative data such as minimum and maximum values, or minimum, maximum and most likely values. The point estimates selected for these parameters were based on assumptions concerning the most conservative park users. The distributional parameters are also based on assumptions concerning park usage. However, the entire range of possibilities (minimum and maximum) expected is used as the input.

The methodology involves seven stages for the analysis:

- Construction of conceptual models
- Building the mathematical models

- Specification of model parameters and their uncertainty
- Model testing and verification
- Conduct systematic sensitivity analysis
- Perform stochastic modeling using common tools such as Monte Carlo or Latin Hypercube Sampling techniques
- Interpretation and presentation of the findings

Each of these stages requires a thorough understanding of the physical situation being modeled and the decisions that are to be made. A quantitative uncertainty analysis is not intended to provide a different answer, but a more complete answer.

Many of these steps were completed in the development of the point estimate PRGs as described in the Risk Assessment Work Plan Addendum (RAWPA)(DOE 1992a). The construction of the conceptual models, building of the mathematical models, specification of model parameters, model testing and verification, and the interpretation and presentation of the point estimate PRGs are presented in the Appendix C of this FS and the RAWPA.

A stochastic model can require considerable resources and modeling time to put together adequate probability density functions and modeled distributions. The uncertainty models developed initially will be limited to focus the study on the pathways and contaminants which present the greatest concern and thus must be modeled more appropriately to provide the risk manager with essential information to base decisions. The actual model parameters which will be selected for quantitative uncertainty analysis will be determined through a model sensitivity study.

The sensitivity analysis was conducted as a part of this study. Only the exposure portion of the models for developing PRGs was assessed. The sensitivity analysis assesses the influence of the input parameters on the outcome of the exposure assessment. The sensitivity analysis identifies those parameters which can greatly impact the results of the PRG development. Greater emphasis is placed on developing the probability distributions for these parameters. The results of the sensitivity analysis identify the parameters which will be discussed in detail due to their importance on influencing the results of PRG development.

The parameters which are selected based on the results of the sensitivity analysis will be researched through literature to determine the best estimate, range and distribution to assess probability density functions (PDFs). These PDFs will be input to the exposure assessment model using spreadsheets and commercially available software to perform Monte Carlo sampling. Modeled output distributions

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will be developed to assess the potential distribution of exposures and associated risks and remedial guidelines.

Other sources of uncertainty will be qualitatively addressed to present a complete discussion on the uncertainty and the potential sources of uncertainty. These other areas include the source term development, transport models, and dose-response. These areas will be presented without quantitative support.

H.VI.2.1 Sensitivity Analysis Results

Distributions for the exposure related input variables were developed, excluding the food pathway. The intake consumption rates for the food pathway were considered to be reasonable and subject to site specific variation. The sensitivity analysis was performed by selecting the preliminary distributions and using the computer program CRYSTALBALL. Following 1,000 simulations using a Monte Carlo sampling technique the program determined the rank correlation coefficient between the output (PRG) and the input parameter. A rank correlation coefficient of greater than 0.5 was considered significant and is developed further. This was done for uranium, arsenic, beryllium and PCBs (Aroclor-1254) for PRGs based on both cancer risk and hazard index.

This process is repeated for each of the three scenarios. The results of the sensitivity analysis are summarized in the tables below. Table H.VI-1 presents the parameters which are significantly correlated to a change in the PRG based on a change in the input, for the Farmer Scenario. Table H.VI-2 presents the results for the Industrial Scenario. Table H.VI-3 presents the sensitivity results for the Developed Park Recreational Scenario.

TABLE H.VI-1

THE RESIDENT FARMER

	Uranium-238		Arsenic		Aroclor	
Parameter	Cancer Risk	HI	Cancer Risk	HI	Cancer Risk	HI
Exposure Duration	X		X		X	
Body Weight		X		X		

TABLE H.VI-2

THE INDUSTRIAL SCENARIO (GROUNDSKEEPER)

	Uranium-238		Arsenic		Aroclor	
Parameter	Risk	HI	Risk	HI	Risk	HI
Exposure Duration	X		X		X	
Soil Ingestion Rate (Adult)			X	X		
Soil Adherence Factor		X			X	

TABLE H.VI-3

THE RECREATIONAL SCENARIO (DEVELOPED PARK)

	Uranium-238		Arsenic		Aroclor	
Parameter	Risk	HI	Risk	HI	Risk	HI
Exposure Duration	X		X		X	
Soil Ingestion Rate (Adult)				X		
Soil Adherence Factor					X	

H.VI.3 EXPOSURE PARAMETER ASSUMPTIONS

The parameters presented in Section V.2.1 are those which have the greatest impact on the results of the PRG development. These parameters are defined better through a literature search to determine the best possible probability distribution for these variables. This section presents a summary of the distribution and the source of the data for each of the significant parameters.

Exposure Duration

The exposure duration will vary based on the scenario. The resident farmer is more likely than other residential scenario settings to remain in a single dwelling/location longer.

Previous FEMP risk assessments have assumed that a residential exposure duration is 70 years based on the guidance in the RAWPA. This value is extremely conservative for most scenarios and at the

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high end of the duration range for the farmer. Data from the U.S. Department of Commerce, Bureau of Census (1988 and 1989) indicate that the average time since moving into the current residence is 10.6 years. The total residence time and the current residence time do not share the same distribution. However, methods have been recently developed to simulate total residence time based on available data. The average total residence time is for all U.S. households was 4.67 years. Only about 5 percent of all households were expected to stay in the same residence greater than 23 years; while half of all households were expected to stay in the same residence for less than 1.5 years. An insignificant fraction were expected to stay at the same residence for an entire lifetime.

A summary of data assembled by Israeli and Nelson (1992) is presented in Table H.VI-4 for the farmer and rural residential scenarios.

TABLE H.VI-4

SELECTED DISTRIBUTION PERCENTILES OF RESIDENTIAL OCCUPANCY PERIOD BY RESIDENCE TYPE

	Percentile (yr)							
Residence Type	5th	10th	25th	50th	75th	90th	95th	99th
Rural (Residential)	0.24	0.48	1.2	3.3	9.1	21.7	32.3	62.4
Resident Farmer	0.48	0.96	2.4	10.0	26.7	48.3	58.4	67.7

The industrial scenario uses the distributions for occupational durations from the U.S. Bureau of Labor Statistics (U.S. DOL 1992). This data is presented in Table H.VI-5.

TABLE H.VI-5

DISTRIBUTION PERCENTILES FOR TIME IN OCCUPATION

Percentile	Years since last job
5th	1.0
10th	1.0
25th	1.0
50th	3.8
75th	11.0
90th	19.0
95th	29.0
100th (maximum)	30

Based on data from the U.S. Bureau of Labor Statistics

Body Weight

The RAWPA recommends the use of 70 kg as the body weight of an adult. This value is a reasonable value to use in risk assessments. The 70 kg values is about the average of the mean 50th percentile value for both men and women across the age spectrum from 18 to 75 years of age. The Exposure Factor handbook (AIHC 1994) presents a distribution of body weight for both men and women as normal distributed about a mean of 72 kg with a standard deviation of 15.9 kg. This distribution was used in all PRG calculations for adults.

Soil Ingestion Rate

The RAWPA recommends a soil ingestion rate of 100 mg/day. This value is the highest default value listed in the 1989 U.S. EPA Exposure Factor Handbook. At the time that this recommendation was made there were no quantitative measurements of soil ingestion in adults (U.S. EPA Exposure Factor Handbook, pp. 2-57). A pilot study has been conducted in adults using a mass balance soil tracer approach. Results of this study are discussed in the Source Book (AIHC 1994, pp. 6.1)

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A conclusion of an evaluation of the detection limits in the soil study was that none of the tracers used in the study demonstrated adequate detection limits for assessing soil ingestion in adults.

The AIHC has attempted to provide some estimate of soil ingestion in adults. A simulated distribution was prepared using the zirconium data which is the most reliable tracer. This distribution indicates that the 100 mg/day is near the 80th percentile of the distribution. The median adult soil ingestion rate from this distribution is much less than 1 mg/day.

Table H.VI-6 represents the custom distribution used for this assessment as presented in the Source Book, pp 6.2 (AIHC 1994).

TABLE H.VI-6

SOIL INGESTION RATE FOR ADULTS

Min	Max	17%	33%	50%	67%	83%	100%
0	216	0	0	0	17	148	216

This data as used would indicate that the point estimate is not conservative at the high end of the risk. The 90th percentile is greater than 100 mg/day.

The soil ingestion rate for children is different than that of adults. The RAWPA and the U.S. EPA have recommended the use of 200 mg/day as the soil ingestion rate for children. The results of the latest studies on soil ingestion rates of children are summarized by Finley et al (1994).

The simulated distribution of child soil ingestion based on the zirconium tracer are presented in the Source Book, pp 6.5. This data was used as the distribution of the child soil ingestion rate and is presented in Table H.VI-7.

TABLE H.VI-7

SOIL INGESTION RATE IN CHILDREN

Min	Max	5%	10%	50%	90%	95%
0	1391	0	0	16	67	110

Soil Adherence Factor

The chemical uptake of via dermal contact with contaminated soils can be a primary exposure pathway. This occurs as a result of activities such as gardening, construction and some recreational activities. There are many areas of potential uncertainty when it comes to assessing the dermal exposure pathway. A review of applicable studies and a recommended distribution for this factor is presented in "Development of a Standard Soil-to-Skin Adherence Probability Density Function for Use in Monte Carlo Analyses of Dermal Exposure" (Finley et al 1994).

The soil adherence factor is not likely to be significantly influenced by site specific conditions. The soil adherence factor was developed from studies based on soil adherence to hands and is likely to overestimate the adherence to other areas of the body (Finley et al 1994). This is due in part due to the skin on the hands containing more grooves and less hair than the arms. Also hands are more likely to come into direct contact with soil than other areas of the body. For these reasons the parameter distribution selected for the soil adherence is considered to be conservative.

The distribution used to represent the range of soil adherence is lognormally distributed with an arithmetic mean of 0.52 mg-soil/cm^2-skin and a standard deviation of 0.9 mg-soil/cm^2-skin. The 95th percentile of this distribution is then 1.7 mg-soil/cm^2-skin. This high end value is greater than the high end value selected for the point estimate calculation.

H.VI.4 RESULTS OF UNCERTAINTY ANALYSIS

The results of the Monte Carlo analysis will yield PRGs based on 10^{-6} incremental lifetime cancer risk (ILCR) and a toxicity value based on a Hazard Index of 0.2. The limiting factor for some scenarios was the risk based PRG while for others it was the toxicity or the HI. The uncertainty analysis, using the Monte Carlo technique presents the PRGs as a range across the entire distribution of potential outcomes.

The PRG represents the soil concentration level which will result in the stated cancer risk or HI from the scenario. These results are based on input variables that were sampled 2,500 times each and the PRG was calculated 2,500 times. The results are then evaluated by Crystalball to present the possible range of outcomes in the form of a probability distribution. The range may vary by several orders of magnitude. However each of these values represents the risk or toxicity at the stated level.

H.VI.4.1 Results for the Farmer Scenario

The calculated PRGs using the Monte Carlo analysis resulted in PRGs which varied over several orders of magnitude. This was expected due to the use of input variables which varied over a couple of orders of magnitude in some cases. The distribution of results of the farmer scenario are shown in Tables H.VI-8 through H.VI-12.

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TABLE H.VI-8

FORECAST OF URANIUM-238 SOIL PRG BASED ON A 10^{-6} CANCER RISK FOR THE RESIDENT FARMER

Percentile	PRG (pCi/g)
0%	2.6×10^{0}
2.5%	6.4×10^{0}
5%	1.0×10^{1}
10%	1.8×10^{1}
25%	4.2×10^{1}
50%	8.1×10^{1}
75%	1.2×10^{2}
90%	1.8×10^{2}
95%	3.4×10^{2}
97.5%	6.5×10^{2}

TABLE H.VI-9

FORECAST OF TOTAL URANIUM SOIL PRG BASED ON AN HQ OF 0.2 FOR THE ON-PROPERTY RESIDENT FARMER

Percentile	PRG (mg/kg)
0%	1.2×10^{1}
2.5%	2.7×10^{1}
5%	3.1×10^{1}
10%	3.4×10^{1}
25%	4.1×10^{1}
50%	4.9×10^{1}
75%	5.8×10^{1}
90%	6.7×10^{1}
95%	7.3×10^{1}
97.5%	7.7×10^{1}

TABLE H.VI-10

FORECAST OF ARSENIC SOIL PRGs BASED ON A 10^{-6} CANCER RISK FOR THE ON-PROPERTY RESIDENT FARMER

Percentile	PRG (mg/kg)
0%	3.0×10^{-2}
2.5%	1.6×10^{-1}
5%	2.8×10^{-1}
10%	5.3×10^{-1}
25%	1.3×10^{0}
50%	2.5×10^{0}
75%	3.8×10^{0}
90%	5.2×10^{0}
95%	1.0×10^{1}
97.5%	1.9×10^{1}

TABLE H.VI-11

FORECAST OF ARSENIC SOIL PRGs BASED ON A HQ OF 0.2 FOR THE ON-PROPERTY RESIDENT FARMER

Percentile	PRG (mg/kg)
0%	1.7×10^{0}
2.5%	4.0×10^{0}
5%	4.5×10^{0}
10%	5.0×10^{0}
25%	6.1×10^{0}
50%	7.2×10^{0}
75%	8.5×10^{0}
90%	9.6×10^{0}
95%	1.0×10^{1}
97.5%	1.1×10^{1}

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TABLE H.VI-12

FORECAST OF PCB PRGs BASED ON A 10^{-6} CANCER RISK FOR THE ON-PROPERTY RESIDENT FARMER

Percentile	PRG (mg/kg)
0%	0.0
2.5%	1.0×10^{-2}
5%	1.0×10^{-2}
10%	2.0×10^{-2}
25%	4.0×10^{-2}
50%	9.0×10^{-2}
75%	1.3×10^{-1}
90%	1.7×10^{-1}
95%	3.6×10^{-1}
97.5%	6.4×10^{-1}

Tables H.VI-8 and H.VI-9 present the PRG for U-238 which was limited by risk, between the 0 to 25th percentile, for the farmer scenario. Above the 25th percentile the limiting factor was the HI due to the fact that the direct radiation exposure has no impact on the toxicity. This provided the limiting factor as opposed to the results based on the HI. A total of 2,500 trials were performed. The U-238 PRG varied from a low value of 0.86 pCi/g to a high value of 650 pCi/g at the 97.5th percentile. The median PRG was 27 pCi/g and the high end PRG (10th percentile) was 6.1 pCi/g.

The PRG for arsenic was still based on risk as the limiting factor at the 10^{-6} level. The arsenic PRGs ranged from 0.03 mg/kg to a high value at the 97.5th percentile of 19 mg/kg. The median value was 2.5 mg/kg while the high end value was 0.53 mg/kg (Tables H.VI-10 and H.VI-11).

The PRG for PCBs was also dependent upon risk. The entire range of potential outcomes for the PCB PRG is 0 to 0.64 mg/kg at the 97.5th percentile. The median value is 0.05 mg/kg. The high end value for PCBs is 0.01 mg/kg (Table H.VI-12).

H.VI.4.2 Industrial Scenario (Groundskeeper)

The calculated PRGs at the 10^{-6} level using the monte carlo analysis resulted in PRGs which varied over several orders of magnitude. This was expected due to the use of input variables which varied by a similar magnitude in some cases. The distribution of results of the industrial scenario are shown in Tables H.VI-13 through H.VI-17.

TABLE H.VI-13

FORECAST OF URANIUM-238 SOIL PRGs BASED ON A 10^{-6} CANCER RISK FOR THE INDUSTRIAL SCENARIO (GROUNDSKEEPER)

Percentile	PRG (pCi/g)
0%	2.6×10^{1}
2.5%	2.4×10^{2}
5%	4.5×10^{2}
10%	8.8×10^{2}
25%	2.2×10^{3}
50%	4.3×10^{3}
75%	6.4×10^{3}
90%	7.7×10^{3}
95%	8.1×10^{3}
97.5%	1.2×10^{4}

TABLE H.VI-14

FORECAST OF URANIUM SOIL PRGs BASED ON A HQ OF 0.2 FOR THE INDUSTRIAL SCENARIO (GROUNDSKEEPER)

Percentile	PRG (mg/kg)
0%	1.4×10^{1}
2.5%	6.3×10^{1}
5%	1.1×10^{2}
10%	2.1×10^{2}
25%	5.1×10^{2}
50%	1.0×10^{3}
75%	1.5×10^{3}
90%	3.0×10^{3}
95%	4.6×10^{3}
97.5%	8.0×10^{3}

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TABLE H.VI-15

FORECAST OF ARSENIC SOIL PRGs BASED ON A 10^{-6} CANCER RISK FOR THE INDUSTRIAL SCENARIO (GROUNDSKEEPER)

Percentile	Carcinogencitiy (mg/kg)
0%	1.8×10^{-1}
2.5%	9.5×10^{2}
5%	1.9×10^{3}
10%	3.8×10^{3}
25%	9.6×10^{3}
50%	1.9×10^{4}
75%	2.9×10^{4}
90%	3.5×10^{4}
95%	3.6×10^{4}
97.5%	6.8×10^{4}

TABLE H.VI-16

FORECAST OF ARSENIC SOIL PRGs BASED ON A HQ OF 0.2 FOR THE INDUSTRIAL SCENARIO (GROUNDSKEEPER)

Percentile	PRG (mg/kg)
0%	4.4×10^{0}
2.5%	8.9×10^{2}
5%	1.8×10^{3}
10%	3.6×10^{3}
25%	8.9×10^{3}
50%	1.8×10^{4}
75%	2.7×10^{4}
90%	4.7×10^{4}
95%	8.1×10^{4}
97.5%	1.4×10^{5}

TABLE H.VI-17

FORECAST OF PCB SOIL PRGs BASED ON A 10^{-6} CANCER RISK FOR THE INDUSTRIAL SCENARIO (GROUNDSKEEPER)

Percentile	PRG (mg/kg)
0%	2.0×10^{-2}
2.5%	6.0×10^{0}
5%	1.2×10^{1}
10%	2.4×10^{1}
25%	6.1×10^{1}
50%	1.2×10^{2}
75%	1.8×10^{2}
90%	2.2×10^{2}
95%	2.3×10^{2}
97.5%	3.9×10^{2}

A total of 2500 trials were performed. For the industrial groundskeeper scenario the limiting factor was the toxicity of uranium with an HI of 0.2. This is because the external exposure and overall duration are not as significant to the HI. The total uranium PRG varied from a low value of 14 mg/kg at the 0 percent to a high of 8,000. The median PRG was 1000 (ppm) mg/kg for the limiting case of HI. The high end PRG (90th percentile) was 210 mg/kg (Table H.VI-14).

The PRG for arsenic was based on toxicity with an HI of 0.2. The arsenic PRGs ranged from 4.4 mg/kg to a maximum of 140,000 mg/kg (Table H.VI-16). The median value was 18,000 mg/kg while the high end value was 3600 mg/kg.

The PRG for PCBs was dependent upon risk. The entire range of potential outcomes for the PCB PRG is 0.02 to 390,000 mg/kg. The median value is 120 mg/kg. The high end value for PCBs is 24 mg/kg (Table H.VI-17).

H.VI.4.3 Recreational Scenario (Developed Park)

A total of 2,500 trials were performed. The distribution of results of the developed park scenario are shown in Tables H.VI-18 through H.VI-21. For the developed park scenario the limiting factor at the high end of the certainty range was the risk from U-238.

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The PRG for arsenic at the high end of the certainty range (90th percentile), were limited based on risk. The arsenic PRGs ranged from 5.9 mg/kg to a maximum of 130,000 mg/kg. The median value was 67,000 mg/kg while the high end value was 13,000 mg/kg (Table H.VI-19).

The PRG for PCBs was dependent upon risk. The entire range of potential outcomes for the PCB PRG was 0.07 to 1700 mg/kg. The median value is 240 mg/kg. The high end value for PCBs is 49 mg/kg (Table H.VI-21).

H.VI.5 CONCLUSIONS AND INTERPRETATIONS

It is important that the "products" of the quantitative uncertainty analysis are presented and discussed to provide an interpretation of the results. The very nature of an uncertainty analysis, whether quantitative or qualitative, addresses relationships between the predicted and the actual. The balance between these two quantities, one of which can never be known precisely, is in fact the rationale for assessing the uncertainty in the first place.

As discussed above the nature of exposure modeling includes numerous areas where errors (uncertainty and variability) can be propagated. The degree to which these errors impact the decision process is the subject of this analyses. This study has illustrated that, with consideration of only a small number of parameters, the potential impact on the decision process can be significant in that the point estimates of the PRGs typically fall in the extreme range of the distribution of potential results.

TABLE H.VI-18

FORECAST OF U-238 SOIL PRGS FOR THE DEVELOPED PARK USER

Percentile	PRG based on 10^{-6} cancer risk (pCi/g)	PRG based on HQ of 0.2 (mg/kg)
0%	5.5×10^{0}	8.1×10^{1}
2.5%	3.0×10^{2}	1.8×10^{2}
5.0%	6.0×10^{2}	2.8×10^{2}
10%	1.2×10^{3}	4.9×10^{2}
25%	2.9×10^{3}	1.1×10^{3}
50%	5.7×10^{3}	2.1×10^{3}
75%	8.7×10^{3}	5.7×10^{3}
90%	1.9×10^{4}	1.6×10^{4}
95%	3.9×10^{4}	2.8×10^{4}
97.5%	9.0×10^{4}	5.0×10^{4}

TABLE H.VI-19

FORECAST OF SOIL ARSENIC PRGs BASED ON A 10^{-6} CANCER RISK FOR THE DEVELOPED PARK USER

Percentile	PRG (mg/kg)
0%	5.9×10^{0}
2.5%	1.2×10^{1}
5.0%	2.4×10^{1}
10%	1.3×10^{4}
25%	3.3×10^{4}
50%	6.7×10^{4}
75%	1.0×10^{5}
90%	1.2×10^{5}
95%	1.3×10^{5}
97.5%	1.3×10^{5}

TABLE H.VI-20

FORECAST OF ARSENIC SOIL PRGS BASED ON A HQ OF 0.2 FOR THE DEVELOPED PARK USER

Percentile	PRG (mg/kg)
0%	2.4×10^{2}
2.5%	5.8×10^{2}
5.0%	9.4×10^{2}
10%	1.6×10^{3}
25%	3.7×10^{3}
50%	7.2×10^{3}
75%	1.4×10^{4}
90%	3.4×10^{4}
95%	6.9×10^{4}
97.5%	1.3×10^{5}

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TABLE H.VI-21

FORECAST OF PCBS SOIL PRGS BASED ON A 10^{-6} CANCER RISK TO THE DEVELOPED PARK USER

Percentile	PRG (mg/kg)
0%	7.1×10^{-2}
2.5%	1.2×10^{1}
5.0%	2.4×10^{1}
10%	4.9×10^{1}
25%	1.2×10^{2}
50%	2.4×10^{2}
75%	3.7×10^{2}
90%	4.4×10^{2}
95%	9.0×10^{2}
97.5%	1.7×10^{3}

The risk manager can use the range of PRGs to select a level of confidence (certainty) with which the PRG is not likely to present a greater risk than the selected risk level. The following specific products will be used to illustrate the potential impact on the final remediation levels:

- The impact on the PRGs by using distributions to define input parameters.
- A potential probability distribution of PRGs directly associated with a given risk in the range of 1×10^{-4} to 1×10^{-6}.
- An estimated value for the percentile range for the Reasonable Maximum Exposed individual for each receptor scenario and associated land use alternative.
- A qualitative discussion of the uncertainty associated with the other aspects of the risk assessment and PRG development process, including; Source term development, fate and transport modeling and related parameters, and dose-response models.

This summary of the specific products, interpretations, and limitations represents a particular view of the overall uncertainty of the estimated risk values. While conservative risk models are sought in the planning process and specifically for determining whether action is required, the same conservative results are not as effective in considering what action needs to be taken. The FS for Operable Unit 5 is a comprehensive approach to that specific evaluation. It is important to understand the role and the

limitations of point estimates of risk in the evaluation of alternatives process. This uncertainty analysis has shown that the conservativism can be significant.

H.VI.5.1 Impact on Preliminary Remediation Goals

The use of conservative assumptions has led to model calculations which are intended to overestimate the actual risks to exposed individuals. Risk assessment guidance is focused on the use of the reasonable maximum exposure as the basis for decisions. The February 1992 Memorandum, from F. Henry Habicht II, concerning additional risk characterization for risk managers and risk assessors clearly identifies that "EPA risk assessments will be expected to address or provide descriptions of individual risk to include the central tendency and the high end portions of the risk distribution." The term "high end" was defined in the memorandum to be above the 90th percentile. Further more the high end risk descriptors are not the worst case or bounding risk estimates. The reasonable maximum exposure is, therefore, expected to be the upper end or high end of the risk potential and should be considered as those values between the 90th to 95th percentile.

The information provided from models which are not "realistic" in their parameter selection is of limited use when the risks are greatly overpredicted. The overprediction stems from the propagation of conservativism in each stage of the risk model. The intent was to obtain high end risks and the actual results are believed to be the extreme risk at the 99th or 99.9th percentile. Emphasis should be placed on removing conservative assumptions and increasing the realism of the model predictions. Given that the CERCLA guidance recommends the use of the RME scenario to determine impacts from contaminants in the environment, then the use of the 90th to 95th percentile exposures indicates that the complete characterization of uncertainty in risk assessment needs to be documented.

Based on the results of the uncertainty analysis using the exposure parameters, the PRG for uranium, for the farmer scenario, is conservative by more than a factor of ten (comparing the point estimate (RME) of 0.42 pCi/g to the 10th percentile of 6.1 pCi/g). It is important to note that there is an inverse relationship between risk and PRGs and thus the percentile for the RME PRG should be between the 5th and the 10th percentile to correspond to a total risk estimate between the 90th and 95th percentile. The overconservativism in the developed park and industrial scenarios for the uranium soil PRG were found to be on the order of 70 and 6, respectively. At a risk level of 10^{-6} a PRG for uranium based on the RME point estimate is approximately 0.42 pCi/g. This point estimate appears on the overall distribution at below the 1st percentile. The 10th percentile corresponds to a value of 6.1 pCi/g.

These values illustrate the estimated risk associated with the farmer scenario, has less than a 1% chance of occurrence. The 10^{-5} risk based PRG at the 10th percentile would be approximately 61 pCi/g.

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This conservativism, in the farmer scenario for uranium, is due primarily to two factors: 1) the exposure duration and 2) the shielding factor. The exposure duration used to represent the point estimate for the resident farmer was taken to be 70 years. The value used, in the point estimates, for a shielding factor for uranium (indoors) was 0.5 (dimensionless). Detailed calculations using the computer code MicroShield for uranium-238 the isotope specific indoor shielding factor is better represented by 0.90.

Using the probabilistic approach and still tending towards the 95th percentile for the risk estimate, and 5th percentile for the PRG, the point estimate is, as stated previously, about an order of magnitude lower than that predicted by the simulation distribution. A more useful estimate of the 10^{-6} risk is the value of 6.1 pCi/g which corresponds to the 10th percentile of the distribution and is therefore still conservative in that there is only a 10% chance that this estimate of the PRG would be lower (or the corresponding risk would be greater). In the recreational park scenario the overestimate was on the order of a 100. The 10th percentile for the developed park user scenario results in a PRG for uranium of 780 pCi/g which corresponds to 2340 ppm for total uranium (recall that under this scenario the residential exposure duration, which is the number of years spent in the vicinity of the park, was used). The point estimate of uranium for the developed park scenario was calculated at 11 pCi/g or 33 ppm, while the undeveloped park (based on an exposure duration of 70 years) has an RME point estimate of 26 pCi/g or 78 ppm.

Given the distribution of the PRGs at the 10^{-6} risk level it is a simple exercise to determine the corresponding values at the 10^{-5} and 10^{-4} levels. The distributions are independent of the dose response and therefore are linear multiples of the original distribution. What is significant here is the ability to evaluate risk equivalence across exposure scenarios. The 10th percentile for the farmer at the 10^{-5} risk level is 61 pCi/g and that relates to the 95th percentile for the undeveloped park user at the 10^{-6} risk level. A table of merely the point estimates for the two scenarios would not have identified this equivalence, since the table of values does not include information pertaining to the relationships between exposure scenarios.

The correlation of the risk distributions for each exposure scenario is best represented by the results in Table H.VI-22.

TABLE H.VI-22

RISK EQUIVALENCE - RME VERSUS PROBABILITY DISTRIBUTION
(PRGs in pCi/g for Uranium-238 for Surface Soil)

Risk	Resident Farmer			Industrial			Developed Park			Undeveloped Park		
	10^{-6}	10^{-5}	10^{-4}	10^{-6}	10^{-5}	10^{-4}	10^{-6}	10^{-5}	10^{-4}	10^{-6}	10^{-5}	10^{-4}
RME	0.42	42	420	4	40	400	11	110	1100	26	260	2600
0*	0.85	8.5	85	8.6	86	860	5.5	55	550	-	-	-
5	3.5	35	350	150	1500	15,000	200	2000	20,000	-	-	-
10	6.1	61	610	290	2900	29,000	390	3900	39,000	-	-	-
25	14	140	1400	720	7200	72,000	960	9600	96,000	-	-	-
50%	27	270	2700	1430	14,300	143,000	1900	19,000	190,000	-	-	-

* - For the Farmer and Industrial scenarios the shielding factor was adjusted as a result of Micro-Shield analysis, as a result the point estimate RME appears to be outside the distribution.

- Indicates values that were not evaluated due to the fact that the point estimate for the RME risk is the basis of the decisions in the Proposed Plan

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In the event that the exposure scenario is altered after remediation is complete (i.e., trespassers, or institutional controls fail) then Table H.VI-22 presents the likely outcome for those scenarios who point estimate resulted in a predicted risk greater than that of the undeveloped park. These scenarios are the industrial groundskeeper, developed park and resident farmer scenarios. The results can be interpreted in terms of the likelihood that the risk would be exceeded should the exposure scenarios change. The representative Operable Unit 5 alternative is based on the implementation of institutional controls to restrict exposures to that of the undeveloped park. In the event that the institutional controls are lost or discontinued the evaluation of the risk can be based on the interpretation of the probability distributions for the various scenarios. These comparisons are the basis for evaluating the risk equivalence.

As an example take the undeveloped park scenario, which has a point estimate of 26 pCi/g for uranium-238, and as compared to the probability distributions of the other scenarios it is clear there is sufficient overlap between the risk estimates to ensure the protection of the public. The 10^{-6} risk based PRG for uranium, under the undeveloped park scenario, is essentially equivalent to the 10^{-5} risk level for the farmer at the 95 percentile. Additionally there is also a direct equivalence to the 10^{-6} risk level for a receptor in the industrial scenario. These results indicate that the 10^{-6} risk level for the undeveloped park scenario would also be protective for all scenarios at the 95 percentile of the simulated distributions for 10^{-5}. Similar results were obtained for representative COCs including arsenic and PCBs. The results are presented in detail in the appendix and were summarized in Section H.VI.

H.VI.5.2 Percentile Range for Reasonable Maximum Exposure (RME)

Another important conclusion of the quantitative uncertainty analysis is the ability to determine where the point estimates for the RME fall on the simulated distribution. In the case of the farmer scenario the RME point estimate falls below the 1st percentile, thereby indicating another measure of the conservativism. The CT point estimate value, which is intended to be at or near the mean, actually falls below the 10th percentile (the risk at that concentration would be above the 90th percentile) for the farmer scenario.

For the other scenarios the results are similar in that the RME point estimate consistently falls at or below the 2.5th percentile of the simulated distribution. It is again important to note that from a statistical point of view the mean represents the "expected" value or the most likely value to be observed upon repeated measures.

H.VI.6 REFERENCES

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ATTACHMENT H.VII
EVALUATION OF RELATIVE RISKS FROM DECAYS AND UNDECAYED RADIOACTIVE CONTAMINANTS

LIST OF TABLES

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H.VII. EVALUATION OF RELATIVE RISKS FROM DECAYS AND UNDECAYED RADIOACTIVE CONTAMINANTS

An estimate of the impact of decay was made using the currently identified radioactive contaminants found at the site. Three cases were evaluated: risk from external radiation based on residual soil concentrations given in Attachment H.III (Table H.III-10), risk from incidental ingestion of soil based on the same soil concentrations, and risk from inhalation of particulates and volatiles based on residual air concentrations given in Table H.3-4. The impact of taking decay fractions into account was done by multiplying the contaminant concentration at 1000 years times the cancer slope factors (CSF) from HEAST (EPA 1994b). Consequentially, the values presented are not true risk values, because the other factors required in risk calculations (such as inhalation rates, exposure duration, unit conversion factors, etc.) were not taken into account. This approach was taken because the exposure parameters would be identical for each radionuclide evaluated and therefore would not impact the results. Unit conversion factors were also not taken into account because the residual concentrations and the toxicity factors were treated as fractions of the numbers presented. Never the less, the calculated values provide a basis of comparison that includes the relative impact of each radionuclide on human health.

Table H.VII-1 gives the radiodecay fractions taken from RadDecay 3.03 (Groves Engineering, 1990) for each residual airborne radionuclide given in Table H.3-4. The first column lists the relatively long-lived subchain parent, the next column lists the short-lived daughters associated with each subchain parent, as described in HEAST (EPA 1994b). For each residual radionuclides present, shown as "Residual Contaminant", the concentration of interest is given in across the top. Some of the residual radionuclides lead to duplicate subchains of decay, and are shown separately in the columns under "Residual Contaminant". The final decay fractions are summed across the table to include the contributions from the various parents.

Table H.VII-2 contains the "relative risk" comparisons for exposure via inhalation. The radionuclides identified in the first column of Table H.VII-2 are the radioisotopes evaluated in the CRARE without taking decay into account. The second column indicates the daughters identified in Table H.VII-1 as potentially significant contributors, based on HEAST (EPA 1994b). These values are then multiplied by the CSFs for inhalation and the "relative risk" is summed for the undecayed "residual contaminants" and the decayed radionuclides.

Table H.VII-3 gives the radiodecay fractions, taken from RadDecay 3.03 (Groves Engineering 1990), for each radionuclide identified as a residual concentration above background (see Attachment H.III, Table H.III-10). Table H.VII-4 gives the "relative risks" for external radiation exposure, calculated

in the same manner as discussed for Table H.VII-2, but using the CSFs for external exposure instead of the CSFs for inhalation. Table H.VII-5 gives the "relative risks" for ingestion calculated in the same manner as discussed for Table H.VII-2, but using the CSFs for ingestion instead of those for inhalation.

The evaluations indicate that taking decay into account will increase the risk by 20 percent for external radiation, and will decrease the risks by a factor of three for ingestion. The inhalation pathway yielded the same results when decay is included as when it is not. Radionuclides such as Cs-137 and Sr-90 will have decayed completely at 1000 years. This is offset somewhat by a buildup of daughters.

The factor of "overestimation" for incidental ingestion of soil and the factor of "underestimation" for external exposures, are within the estimated uncertainty expected from the dose models and pathways parameter variability, which were discussed in section H.5.0 and Table H.5-1.

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TABLE H.VII-1

ESTIMATE OF AIR CONCENTRATIONS USING DECAYED RESIDUAL CONCENTRATIONS

Long-lived Parent	Short-lived Daughter	Initial Concentrations at Year 0 (pCi/m³)[a] U-238	U-235	U-234	Th-232	Th-230	Ra-228	Ra-226	(Decay fraction) x (initial concentration)
		3.5 x 10^{-6}	4.7 x 10^{-8}	0	6.0 x 10^{-7}	1.3 x 10^{-6}	0	8.2 x 10^{-7}	pCi/m³
		Decayed Fractions Remaining at 1000 y for:							
Th-232					1.0				6.00 x 10^{-7}
Ra-228					1.0				6.00 x 10^{-7}
	Ac-228				1.0				6.00 x 10^{-7}
Th-228					1.0				6.00 x 10^{-7}
	Ra-224				1.0				6.00 x 10^{-7}
	Rn-220				1.0				6.00 x 10^{-7}
	Po-216				1.0				6.00 x 10^{-7}
	Pb-212				1.0				6.00 x 10^{-7}
	Bi-212				1.0				6.00 x 10^{-7}
	Tl-208				3.6 x 10^{-1}				2.16 x 10^{-7}
	Po-212				6.4 x 10^{-1}				3.84 x 10^{-7}
U-238		1.0							3.5 x 10^{-6}
	Th-234	1.0							3.5 x 10^{-6}
	Pa-234m	1.0							3.5 x 10^{-6}
	Pa-234	1.6 x 10^{-3}							5.6 x 10^{-9}
U-234		2.8 x 10^{-3}		1.0					9.8 x 10^{-9}
Th-230		1.3 x 10^{-5}		8.9 x 10^{-3}					4.6 x 10^{-11}
Ra-226		1.7 x 10^{-6}		1.7 x 10^{-3}					6.0 x 10^{-12}
	Rn-222	1.7 x 10^{-6}		1.7 x 10^{-3}					6.0 x 10^{-12}

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TABLE H.VII-1
(Continued)

Long-lived Parent	Short-lived Daughter	Initial Concentrations at Year 0 (pCi/m^3)[a] U-238 3.5×10^{-6}	U-235 4.7×10^{-8}	U-234 0	Th-232 6.0×10^{-7}	Th-230 1.3×10^{-6}	Ra-228 0	Ra-226 8.2×10^{-7}	(Decay fraction) x (initial concentration) pCi/m^3
		Decayed Fractions Remaining at 1000 y for:							
	Po-218	1.7×10^{-6}		1.7×10^{-3}					6.0×10^{-12}
	Pb-213	1.7×10^{-6}		1.7×10^{-3}					6.0×10^{-12}
	Bi-214	1.7×10^{-6}		1.7×10^{-3}					6.0×10^{-12}
	Po-214	1.7×10^{-6}		1.7×10^{-3}					6.0×10^{-12}
Pb-210		1.5×10^{-6}		1.6×10^{-3}					5.3×10^{-12}
	Bi-210	1.5×10^{-6}		1.6×10^{-3}					5.3×10^{-12}
	Po-210	1.5×10^{-6}		1.6×10^{-3}					5.3×10^{-12}
U-235			1.0						4.65×10^{-8}
	Th-231		1.0						4.7×10^{-8}
Pa-231			2.1×10^{-2}						9.8×10^{-10}
Ac-227			2.0×10^{-2}						9.3×10^{-10}
	Fr-223		2.8×10^{-4}						1.3×10^{-11}
	Ra-223		2.0×10^{-4}						9.3×10^{-12}
	Rn-219		2.0×10^{-4}						9.3×10^{-12}
	Po-215		2.0×10^{-4}						9.3×10^{-12}
	Pb-211		2.0×10^{-4}						9.3×10^{-12}
	Bi-211		2.0×10^{-4}						9.3×10^{-12}
	Tl-207		2.0×10^{-4}						9.3×10^{-12}
	Po-211		5.5×10^{-5}						2.66×10^{-12}
	Th-227		2.0×10^{-2}						9.3×10^{-10}

a Concentrations from Table H.3-4

TABLE H.VII-2

COMPARISON OF IMPACT OF DECAYED RADIONUCLIDE ACTIVITIES TO UNDECAYED, AT 1000 YRS

	Decay daughters	CSF inhalation (risk/pCi)	Residual Air (pCi/m^3)	Res. Air x CSF ("risk")	Decayed Quantity (pCi/m^3) (1)	Dec. Quantity x CSF ("risk")
Pb-210	+ 2 d	4.0×10^{-9}	0.0	0.0	5.3×10^{-12}	0
Ra-226	+ 8d	7.0×10^{-9}	8.2×10^{-7}	5.7×10^{-15}	NA	
	+ 5d	3.0×10^{-9}			6.0×10^{-12}	1.80×10^{-20}
	Pb-210 + 2d	SA			(2)	0
Tc-99		8.3×10^{-12}	1.4×10^{-7}	1.2×10^{-18}	1.4×10^{-7}	1.16×10^{-18}
Th-228	+ 7d	7.8×10^{-8}	0.0	0.0	6.0×10^{-7}	4.68×10^{-14}
Th-230		2.9×10^{-8}	1.3×10^{-6}	3.8×10^{-14}	4.6×10^{-11}	1.33×10^{-18}
Th-232	+ 10 d	1.07×10^{-7}	6.0×10^{-7}	1.7×10^{-14}	NA	
	no d	2.8×10^{-8}			6.0×10^{-7}	1.68×10^{-14}
	Ra-228 + 1d	6.9×10^{-10}			6.0×10^{-7}	4.14×10^{-16}
	Th-228 + 7d	SA			(2)	0
U-234		2.6×10^{-8}	0.0	0.0	9.8×10^{-9}	2.55×10^{-16}
	Th-230	SA			(2)	0
	Ra-226 + 5d	SA			(2)	
	Pb-210 + 2d	SA			(2)	
U-235/236	+ 1d	2.5×10^{-8}	4.6×10^{-8}	1.2×10^{-15}	4.7×10^{-8}	1.18×10^{-15}
	Pa-231	3.6×10^{-8}			9.8×10^{-10}	3.53×10^{-17}
	Ac-227 + 9d	8.8×10^{-8}			9.3×10^{-10}	8.18×10^{-17}
U-238	+ 2 d	2.4×10^{-8}	3.6×10^{-6}	8.6×10^{-14}	3.5×10^{-6}	8.40×10^{-14}
	U-234	SA			(2)	
	Th-230	SA			(2)	
	Ra-226 + 5d	SA			(2)	
	Pb-210 + 2d	SA			(2)	
Totals				1.5×10^{-13}		1.50×10^{-13}

1 Assumes no daughters exist at year 0
2 Contribution included as total in the first listing of that radionuclide
SA = See above listed value for that radionuclide

TABLE H.VII-3

ESTIMATE OF SOIL CONCENTRATIONS USING RESIDUAL SOIL CONCENTRATIONS

Long-lived Parent	Short-lived Daughter	Initial Concentrations at Year 0							(Decayed fraction) x (initial conc.)
		U-238	U-235	U-234	Th-232	Th-230	Ra-228	Ra-226	
		2.8×10^{0}	0.0	0.0	3.2×10^{-2}	6.5×10^{-1}	0	3.8×10^{-1}	pCi/kg
		Decayed Fraction Remaining at 1000 yr for:							
Th-232					1.0×10^{0}				3.2×10^{-2}
Ra-228					1.0×10^{0}		0.0		3.2×10^{-2}
	Ac-228				1.0×10^{0}		0.0		3.2×10^{-2}
Th-228					1.0×10^{0}		0.0		3.2×10^{-2}
	Ra-224				1.0×10^{0}		0.0		3.2×10^{-2}
	Rn-220				1.0×10^{0}		0.0		3.2×10^{-2}
	Po-216				1.0×10^{0}		0.0		3.2×10^{-2}
	Pb-212				1.0×10^{0}		0.0		3.2×10^{-2}
	Bi-212				1.0×10^{0}		0.0		3.2×10^{-2}
	Tl-208				3.6×10^{-1}		0.0		1.1×10^{-2}
	Po-212				6.4×10^{-1}		0.0		2.0×10^{-2}
U-235			1.0×10^{0}						0.0
	Th-231		1.0×10^{0}						0.0
Pa-231			2.1×10^{-2}						0.0
Ac-227			2.0×10^{-2}						0.0
	Fr-223		2.8×10^{-4}						0.0
	Ra-223		2.0×10^{-4}						0.0
	Rn-219		2.0×10^{-4}						0.0
	Po-215		2.0×10^{-4}						0.0
	Pb-211		2.0×10^{-4}						0.0

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TABLE H.VII-3
(Continued)

Long-lived Parent	Short-lived Daughter	Initial Concentrations at Year 0							(Decayed fraction) x (initial conc.)
		U-238	U-235	U-234	Th-232	Th-230	Ra-228	Ra-226	
		2.8×10^{0}	0.0	0.0	3.2×10^{-2}	6.5×10^{-1}	0	3.8×10^{-1}	pCi/kg
		Decayed Fraction Remaining at 1000 yr for:							
	Bi-211		2.0×10^{-4}						0.0
	Tl-207		2.0×10^{-4}						0.0
	Po-211		5.5×10^{-5}						0.0
	Th-227		2.0×10^{-2}						0.0
U-238		1.0×10^{0}							2.8×10^{0}
	Th-234	1.0×10^{0}							2.8×10^{0}
	Pa-234m	1.0×10^{0}							2.8×10^{0}
	Pa-234	1.6×10^{-3}							4.4×10^{-3}
U-234		2.8×10^{-3}		1.0×10^{0}					7.8×10^{-3}
Th-230		1.3×10^{-3}		8.9×10^{-3}		9.9×10^{-1}			6.4×10^{-1}
Ra-226		1.7×10^{-6}		1.7×10^{-3}		3.5×10^{-1}		6.5×10^{-1}	4.8×10^{-1}
	Rn-222	1.7×10^{-6}		1.7×10^{-3}		3.5×10^{-1}		6.5×10^{-1}	4.8×10^{-1}
	Po-218	1.7×10^{-6}		1.7×10^{-3}		3.5×10^{-1}		6.5×10^{-1}	4.8×10^{-1}
	Pb-213	1.7×10^{-6}		1.7×10^{-3}		3.5×10^{-1}		6.5×10^{-1}	4.8×10^{-1}
	Bi-214	1.7×10^{-6}		1.7×10^{-3}		3.5×10^{-1}		6.5×10^{-1}	4.8×10^{-1}
	Po-214	1.7×10^{-6}		1.7×10^{-3}		3.5×10^{-1}		6.5×10^{-1}	4.8×10^{-1}
Pb-210		1.5×10^{-6}		1.6×10^{-3}		3.4×10^{-1}		6.6×10^{-1}	4.7×10^{-1}
	Bi-210	1.5×10^{-6}		1.6×10^{-3}		3.4×10^{-1}		6.6×10^{-1}	4.7×10^{-1}
	Po-210	1.5×10^{-6}		1.6×10^{-3}		3.4×10^{-1}		6.6×10^{-1}	4.7×10^{-1}

1 From Table H.III-10

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TABLE H.VII-4

COMPARISON OF IMPACT OF DECAYED RADIONUCLIDE ACTIVITIES TO UNDECAYED, AT 1000 YRS EXTERNAL RADIATION EXPOSURE CASE

	Decay daughters	CSF external (risk/pCi)	Residual Soil (pCi/kg)	Res. Soil x CSF ("risk")	Decayed Quantity [3] (pCi/kg)	Dec. Quantity x CSF ("risk")
Ra-226	+ 8d	6.0×10^{-6}	3.8×10^{-1}	2.3×10^{-6}		
	+ 5d	6.0×10^{-6}			4.8×10^{-1}	2.9×10^{-6}
	Pb-210 + 2d	1.6×10^{-10}			4.7×10^{-1}	7.5×10^{-11}
Sr-90	+ 1d	0	1.2×10^{-1}	0.0	0	0.0
Tc-99		6.0×10^{-13}	2.5×10^{-1}	1.5×10^{-13}	2.5×10^{-1}	1.5×10^{-13}
Th-228	+ 7d	5.6×10^{-6}	0.0	0.0	3.2×10^{-2}	1.8×10^{-7}
Th-230		5.4×10^{-11}	6.5×10^{-1}	3.5×10^{-11}	7.8×10^{-3}	4.2×10^{-13}
Th-232	+ 10 d	8.5×10^{-6}	3.2×10^{-2}	2.7×10^{-7}		
	no d	2.6×10^{-11}			3.2×10^{-2}	8.3×10^{-13}
	Ra-228 + 1d	2.9×10^{-6}			3.2×10^{-2}	9.3×10^{-8}
	Th-228 + 7d	(1)				
U-234	no d	3.0×10^{-11}	0.0	0.0	7.8×10^{-3}	2.3×10^{-13}
	Th-230	(2)				
	Ra-226 + 5d	(2)				
	Pb-210 + 2d	(2)				
U-235/236 2	+ 1d	2.5×10^{-8}	0.0	0.0	0.0	0.0
	Pa-231	2.6×10^{-8}			0.0	0.0
	Ac-227 + 9d	8.5×10^{-7}			0.0	0.0
U-238	+ 2 d	5.1×10^{-8}	2.8×10^{0}	1.4×10^{-7}	2.8×10^{0}	1.4×10^{-7}
	U-234	(2)				
	Th-230	(2)				
	Ra-226 + 5d	(2)				
	Pb-210 + 2d	(2)				
Totals				2.7×10^{-6}		3.3×10^{-6}

1 Contribution included as total in first listing for radionuclide
2 Assumes all U-235
3 Assumes no daughters at year 0

000952

TABLE H.VII-5

COMPARISON OF IMPACT OF DECAYED RADIONUCLIDE ACTIVITIES TO UNDECAYED, AT 1000 YRS INGESTION EVALUATION

	Decay daughters	CSF ingestion (per pCi)	Residual Soil (pCi/kg)	Res. Soil x CSF ("risk")	Decayed Quantity 3 (pCi/kg)	Dec. Quan x CSF ("risk")
Ra-226	+ 8d	7.8×10^{-10}	3.8×10^{-1}	3.0×10^{-10}		
	+ 5d	1.2×10^{-10}			4.8×10^{-1}	$5.8 \times 10^{-}$
	Pb-210 + 2d	6.6×10^{-10}				
Sr-90	+ 1d	3.6×10^{-11}	1.2×10^{-1}	4.3×10^{-12}	0	0.0
Tc-99		1.3×10^{-12}	2.5×10^{-1}	3.3×10^{-13}	2.5×10^{-1}	$3.3 \times 10^{-}$
Th-228	+ 7d	5.5×10^{-11}	0.0	0.0	3.2×10^{-2}	$1.8 \times 10^{-}$
Th-230		1.3×10^{-11}	6.5×10^{-1}	8.5×10^{-12}	7.8×10^{-3}	$1.0 \times 10^{-}$
Th-232	+ 10 d	1.7×10^{-10}	3.2×10^{-2}	5.4×10^{-12}		
	no d	1.2×10^{-11}			3.2×10^{-2}	$3.8 \times 10^{-}$
	Ra-228 + 1d	1.0×10^{-10}			3.2×10^{-2}	$3.2 \times 10^{-}$
	Th-228 + 7d	(1)				
U-234	no d	1.6×10^{-11}	0.0	0.0	7.8×10^{-3}	$1.2 \times 10^{-}$
	Th-230	(2)				
	Ra-226 + 5d	(2)				
	Pb-210 + 2d	(2)				
U-235/236 2	1d	1.6×10^{-11}	0.0	0.0	0.0	0.0
	Pa-231	9.2×10^{-11}			0.0	0.0
	Ac-227 + 9d	3.5×10^{-10}			0.0	0.0
U-238	+ 2d	2.0×10^{-11}	2.8×10^{0}	5.6×10^{-11}	2.8×10^{0}	$5.6 \times 10^{-}$
	U-234	(2)				
	Th-230	(2)				
	Ra-226 + 5d	(2)				
	Pb-210 + 2d	(2)				
Totals				3.7×10^{-10}		$1.2 \times 10^{-}$

1 Contribution included as total in first listing for radionuclide
2 Assumes all U-235
3 Assumes no daughters at year 0

APPENDIX I

NATIONAL ENVIRONMENTAL POLICY ACT CUMULATIVE IMPACT ANALYSIS

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LIST OF ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirements
AWWT	advanced wastewater treatment (facility)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm	centimeters
COE	U.S. Army Corp of Engineers
CRARE	comprehensive response action risk evaluation
CRP	chlorosulfanated reinforced polyethylene
dB	decibel
dBA	decibel (A-Weighted)
DCG	derived concentration guideline
DDT	dichlorodiphenyl trichloroethane
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EA	environmental assessment
EDE	effective dose equivalent
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EPDM	ethylene-propylene-diene monomer
EWMF	engineered waste management facility
FEMP	Fernald Environmental Management Project
FONSI	finding of no significant impact
FS	feasibility study
ft	feet
ft^2	square feet
gpm	gallons per minute
HI	Hazard Index
in.	inch
kg	kilogram
km^2	square kilometers
L	liter
lbs	pounds
LRA	leading remedial alternative
m	meters
m^2	square meters
m^3	cubic meters
mi^2	square miles

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MSL	mean sea level
NAFB	Nellis Air Force Base
NEPA	National Environmental Policy Act
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NOEL	no observed effect level
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NTS	Nevada Test Site
OAC	Ohio Administrative Code
PBRA	preliminary baseline risk assessment
PCB	polychlorinated biphenyl
pCi	picocuries
PP	proposed plan
ppb	parts per billion
PRG	preliminary remediation goal
rad	radiation absorbed dose
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROD	record of decision
s	second
SWCR	Site-wide Characterization Report
TCLP	toxicity characteristic leaching procedure
U	uranium
UF_4	green salt
UO_3	uranium oxide (orange oxide)
WEMCO	Westinghouse Environmental Management Company of Ohio
yd^3	cubic yards

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I.1.0 INTRODUCTION

I.1.1 PURPOSE

This appendix provides a cumulative assessment of the impacts that would result from implementing the Operable Unit 5 representative alternative (i.e., the alternative most likely to be selected based on the feasibility study [FS] evaluation), with the preferred alternatives or leading remedial alternatives (LRAs) for each of the remaining four operable units at the Fernald Environmental Management Project (FEMP) site.

Preliminary LRAs for Operable Units 1 through 5 were developed in the Site-wide Characterization Report (SWCR) (DOE 1993) and are considered LRAs until they are analyzed in an FS document. For the purpose of an FS evaluation, the term representative alternative is used. Representative alternatives are those alternatives analyzed in the FS document that are likely to be selected based on preliminary information. The term preferred alternative identifies those alternatives selected in the proposed plan based on detailed analysis in the FS.

This assessment provides the reader with the most current information on how the potential impacts from Operable Units 1, 2, 3, and 4 relate to the potential impacts of Operable Unit 5. This appendix is an update of the cumulative impact analysis provided in the Operable Unit 4 Feasibility Study/Proposed Plan-Environmental Impact Statement (FS/PP-EIS) and the Operable Units 1 and 2 Feasibility Study/Proposed Plan (FS/PP). The description of the Operable Unit 5 representative alternative has changed slightly from those evaluated in the Operable Units 1, 2, and 4 documents; therefore, this appendix is being updated for the Operable Unit 5 evaluation.

In this evaluation, efforts have been made to further quantify impacts in the cumulative impact analysis. After the identification of the preferred alternatives for Operable Units 1, 2, and 4, and the representative alternative for Operable Unit 5, impacts to wetlands, biotic resources, etc., can now be more accurately quantified. The original cumulative impact analysis for the Operable Unit 4 FS/PP-EIS evaluated cumulative impacts based on preliminary LRAs identified in the SWCR, which assumed on-site disposal for all operable units.

In addition, analysis related to noise impacts and transportation has been added, because it appears that more of the remedial activities will involve off-site transportation than first envisioned. It is important to note that for Operable Unit 3, this cumulative assessment is still based on the preliminary LRA, consistent with the Implementation Plan for the National Environmental Policy Act (NEPA) process at the FEMP site (DOE 1994a). Additional data will be collected and analyzed for Operable Unit 3 as this operable unit progresses through the Comprehensive Environmental Response,

Compensation, and Liability Act (CERCLA) Remedial Investigation/ Feasibility Study (RI/FS) process. As additional information becomes available and/or the leading remedial alternative changes, revisions to this appendix will be presented in the FS Report for Operable Unit 3.

I.1.2 NEPA/CERCLA INTEGRATION APPROACH AT THE FEMP SITE

It is DOE policy to integrate NEPA values into the CERCLA process wherever practical. Integration is intended to (1) avoid duplicate effort and additional resources that would be needed to implement both NEPA and CERCLA separately, (2) avoid conflicts in analysis and the selection of a remedial alternative, and (3) minimize the risk of delaying remedial actions on procedural grounds. The primary instrument for DOE's NEPA/CERCLA integration is the RI/FS process, supplemented as needed to address NEPA values. The final product is to be a single integrated set of documents--a RI Report, a FS Report, and a PP that satisfies the requirements of CERCLA and addresses NEPA values.

The notice of intent (NOI) for the NEPA/CERCLA integration approach was published in the Federal Register and concluded that (1) a FS/PP-EIS was the appropriate level of NEPA documentation for the lead operable unit (i.e., Operable Unit 4) and (2) NEPA/CERCLA integration is also to be provided in the remaining four operable unit FS/PP reports. The FS/PP for Operable Units 1 and 2 contain a discussion of common issues and potential cumulative impacts, referencing the Operable Unit 4 FS/PP-EIS as the lead document. All subsequent operable unit reports, such as this cumulative impact analysis for the Operable Unit 5 FS, also reference the material presented in the Operable Unit 4 FS/PP-EIS. This evaluation will update available information, as appropriate, and contain adequate operable unit-specific data to support the complete NEPA impact analyses to be contained in each operable unit FS.

On June 13, 1994, DOE issued a revised policy for NEPA compliance. The revised policy, "Secretarial Policy Statement of National Environmental Policy Act," allows for only the values of NEPA to be integrated into the development of CERCLA RI/FS documentation. The revised policy, which is contingent upon stakeholder approval, would allow for reliance on the CERCLA process to meet the procedural requirements of NEPA. Therefore, DOE has supplemented the evaluations contemplated by RI/FS guidance to accommodate the evaluation of NEPA values in the preparation of this FS. This information is also summarized in the Operable Unit 5 Proposed Plan. Additional details on this integration process for addressing NEPA values in the RI/FS process can be found in Section 1.4 of this document.

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I.1.3 REPORT ORGANIZATION

The descriptions of proposed remedial alternatives for Operable Unit 5 are contained in the main text of this FS Report; environmental impact analyses of Operable Unit 5 alternatives are contained in the detailed analysis of alternatives in Section 4.0. The SWCR contains the baseline data required for analyses of potential impacts of site-wide remediation, including a baseline ecological risk assessment. The Operable Unit 5 PP presents the preferred alternative and summarizes the impacts of implementation. Section I.2.0 contains a description of the preferred alternative or LRA for each operable unit. The cumulative environmental impacts of proposed on-property actions are described in Section I.3.0, which analyzes the potential impacts on the environment from concurrent implementation of remedial activities for the operable units and site-wide facilities.

Federal, state, and local agencies consulted during the compilation of data for the FS/PP-NEPA evaluation and the relationship of remediation at the FEMP site to the objectives of local, state, regional, and federal land use plans, policies, and controls, are described in Section I.4.0. An updated discussion of irreversible and irretrievable commitment of resources resulting from remedial activities at the FEMP site is in Section I.5.0.

I.1.4 SCOPE OF CUMULATIVE IMPACT ANALYSIS

The detailed evaluation in this cumulative impact analysis has been limited to impacts on and immediately adjacent to the FEMP site. The activities on adjacent lands which are not related to the FEMP site will not impose significant cumulative impacts to the environment when combined with remediation activities at the FEMP. These activities will be addressed in this section. The cumulative impacts of remediating Operable Units 1 through 5 will be addressed in Section I.3.0.

The specific sites separate from the FEMP site that warrant some discussion of cumulative impacts include:

- A CERCLA site immediately south of the FEMP site (approximately one mile) that is undergoing the RI/FS process for an organic contamination plume in the Great Miami Aquifer. Two other sites are being evaluated as potential CERCLA sites but their proximity to the FEMP site does not justify or warrant a discussion.
- A small quarry located less than a mile from the eastern boundary of the FEMP site.
- The potential for disposal of waste at an off-property location. The remaining areas around the FEMP site are primarily used for agricultural (i.e., cultivated fields) and limited residential domains.

Groundwater remediation at the Fernald site and the CERCLA site south of the Fernald site resulted in the evaluation of potential increases in contaminant loading to the Great Miami River and the possibility of land subsidence due to groundwater extraction. The contaminant loading in the Great

Miami River will be nondetectable to minimal due to the treatment of the extracted groundwater before discharge. The groundwater does not act as a physical support mechanism in this geologic structure; therefore, the possibility of land subsidence is remote.

Activities at the quarry east of the site involve some excavation and movement of soil and rock and is in the prevailing wind direction from the FEMP site. However, the quarry operation is on a relatively small scale when compared to the overall remediation of the FEMP site. In addition, cultivated fields are the predominant land use downwind of both the quarry site and the FEMP site. Therefore, the cumulative impacts associated with dust emissions from the quarry and the site will be minimal.

Fugitive dust from cultivated fields adjacent to the site, in combination with that associated with the excavation and transportation to and from the site, pose a very limited potential for cumulative impacts. These cumulative impacts to air quality will be minimal since (1) the dust remains suspended for a limited time and (2) the number of downwind receptors is limited. The focus of the detailed analysis in this appendix will, therefore, be limited to the concurrent response actions for the five operable units carried out at the FEMP site because their cumulative impacts to the environment and residents in the region are distinctly greater than those in combination with other activities in the area.

Efforts have been made throughout the cumulative impact analysis to quantify impacts to the extent possible. For example, impacts to wetlands and habitats have been quantified (i.e., estimation of acres disturbed) wherever possible. In addition, the overall impacts of the FEMP remedial activities on the local socioeconomic structure have been quantified to the extent possible. Due to the timing of the remedial activities, quantitative information was not available in all cases. In these situations, a qualitative evaluation of potential impacts has been provided.

I.1.5 SITE-WIDE ECOLOGICAL RISK ASSESSMENT

A preliminary site-wide ecological risk assessment in the SWCR estimated the potential and future baseline risks of FEMP contaminants to ecological receptors. The U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) agreed that the next iteration would be done as part of the Operable Unit 5 RI Report. The Site-Wide Ecological Risk Assessment, Appendix B of the Operable Unit 5 RI Report (DOE 1994e), assesses the possible risks from current concentrations of site contaminants to ecological receptors inhabiting on- and off-property areas not presently targeted for remediation based on human health concerns.

I.2.0 LEADING REMEDIAL ALTERNATIVES

This section contains descriptions of each of the operable units at the FEMP site and identifies the leading remedial alternatives for Operable Units 1, 2, 3, and 4. For Operable Unit 5, this section summarizes the description of the representative alternative, which is presented in detail in the FS and PP evaluations. The no-action alternative for the site was evaluated in detail in the SWCR (DOE 1993) and the cumulative impact analysis (Appendix I) of the Operable Unit 4 FS/PP-EIS (DOE 1994b).

The FEMP site was divided into five operable units under the original 1990 Consent Agreement. However, the definitions of the operable units have been revised under the Amended Consent Agreement, and the possibility of a comprehensive site-wide operable unit has been added. The five operable units and their revised definitions are presented below:

- Operable Unit 1 - Waste Pits 1 through 6, the Clearwell, the burn pit, berms, liners, and associated contaminated soil within the operable unit boundary
- Operable Unit 2 - the active and inactive flyash piles, the South Field, the lime sludge ponds, the solid waste landfill, berms, liners, and associated contaminated soil within the operable unit boundary
- Operable Unit 3 - the former production area and production-associated facilities and equipment (includes all above- and below-grade improvements) including, but not limited to, all structures, equipment, utilities, drums, tanks, solid waste, waste, product, thorium, effluent lines, K-65 transfer line, waste water treatment facilities, fire training facilities, scrap metal piles, feedstocks, and the coal pile
- Operable Unit 4 - Silos 1, 2, 3, and 4, berms, the decant sump tank system, and associated contaminated berms and soil within the operable unit boundary
- Operable Unit 5 - perched and regional groundwater, surface water, soil not associated with other operable units, sediment, flora, and fauna

I.2.1 OPERABLE UNIT 1

Operable Unit 1 includes six low-level radioactive waste storage pits, the Burn Pit, and the Clearwell, all located west of the former production area (Figure I.2-1). The pits contain large quantities of liquid and solid wastes that were generated by the various operations at the FEMP site and disposed of before 1987. The Operable Unit 1 waste units are described below. A detailed description of the nature and extent of contamination associated with Operable Unit 1 is provided in the RI Report for Operable Unit 1 (DOE 1994d).

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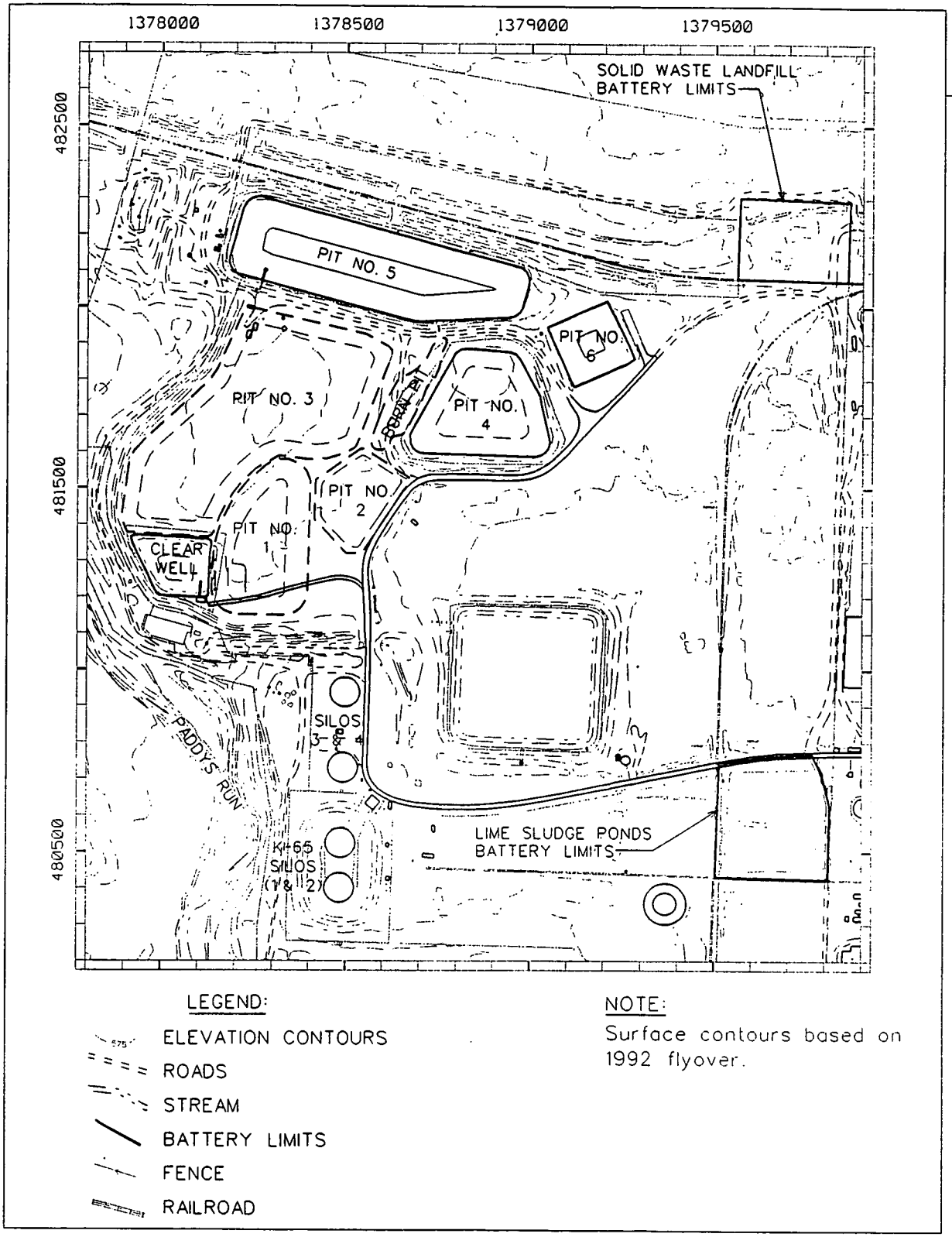

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FIGURE I.2-1. WASTE STORAGE AREA

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- Waste Pit 1 - constructed in 1952 into existing native clay and then lined with an additional 4 feet (ft) of clay. The pit has a maximum depth of 29.5 ft. Contents of the waste pit include 48,500 cubic yards of waste and 19,900 cubic yards of contaminated cap and soil liner. Waste Pit 1 has been out of service since 1959, when it was backfilled, covered with clean soil, and graded to provide surface drainage into the Clearwell.

- Waste Pit 2 - constructed in 1957 and lined with native clay with a 13.8-ft average design depth and a maximum depth of 23.5 ft. Contents of the waste pit include 24,200 cubic yards of waste and 13,200 cubic yards of contaminated cap and liner soil. Waste Pit 2 has been out of service since 1964, when it was backfilled and covered with clean soil.

- Waste Pit 3 - constructed in 1958 by excavating into underlying glacial till and then adding a clay liner along the pit walls and bottom. The pit has a maximum depth of 42.0 ft. The contents of the waste include 204,100 cubic yards of waste and 103,400 cubic yards of contaminated cap and liner soil. Waste Pit 3 has been out of service since 1977, when it was backfilled and covered with clean soil.

- Waste Pit 4 - clay-lined pit constructed in 1960 with a 32 ft maximum depth. Contains an estimated 23,500 pounds (lbs) of barium chloride in addition to radioactive wastes. In 1984, an interim cap providing an additional cover of compacted clay overlain by a 45-mil-thick Hypalon chlorosulfanated reinforced polyethylene (CRP) liner was installed to further ensure segregation of encapsulated materials from surface water during the interim period prior to implementation of a final remedial action. Contents of the waste pit include 55,100 cubic yards of waste and 17,700 cubic yards of contaminated cap and liner soils. In 1986, it was backfilled and covered with clean soil.

- Waste Pit 5 - constructed in 1968 and served as a settling pond for slurried waste from various production processes. It is a maximum 29 ft-deep pond lined with a 60-mil-thick Royal-Seal ethylene-propylene-diene monomer (EPDM) elastomeric membrane. When heavy rainfall occurs, storm water overflow from Pit 5 flows by gravity from the pit to the Clearwell. Contents of the waste pit include 97,900 cubic yards of waste covered with water. Waste Pit 5 has been out of service since 1987.

- Waste Pit 6 - constructed in 1979, this pit is a 24 ft-deep pond lined with a 60-mil-thick Royal-Seal EPDM elastomeric membrane. The pit has been out of service since 1986 and has not been covered. The waste pit contains 9600 cubic yards of waste and standing water remains trapped within the berms of the pit. When heavy rainfall occurs, storm water overflow from Pit 6 flows to Pit 5 and then to the Clearwell.

- The Burn Pit - excavated in 1957 as a clay borrow pit for lining Waste Pits 1 and 2. The depth and size of the pit are not precisely known, but it is estimated to be approximately 30 ft deep. The pit was subsequently used for the disposal and burning of laboratory chemicals, waste oils, and other low-level radioactivity-contaminated materials such as wooden pallets. The pit contains 30,300 cubic yards of mixed waste and soil.

- The Clearwell - constructed in 1959 and served as a settling basin for process water and storm water runoff from the waste pits. The Clearwell contains 4300 cubic yards of sludge and contaminated liner soil. Most recently, the Clearwell was used as a final settling basin for process water that passed through Waste Pit 5 before its discharge to the Great Miami River via the National Pollutant Discharge Elimination System (NPDES) permitted discharge. This use was terminated in March 1987 when Waste Pit 5 was removed from the process water treatment scheme. The Clearwell currently receives surface water runoff from the majority of the surfaces of Waste Pits 1, 2, and 3 and from the entire surface of Waste Pit 5. Water of varying depth remains in the Clearwell at all times. The sediment resulting from material deposition were removed on at least one occasion during the period of operation. The depth of sediment remaining in the Clearwell is estimated at 27 ft.

I.2.1.1 Preferred Alternative for Operable Unit 1

The preferred alternative (as identified in the Operable Unit 1 FS/PP) for Operable Unit 1 involves the removal and treatment of materials from Waste Pits 1 through 6, the burn pit, and the Clearwell to achieve risk-based preliminary remediation goals (PRGs) and applicable or relevant and appropriate requirements (ARARs). The excavated area will be backfilled with clean soils. The excavated materials will be treated (dried) and transported by rail to a commercial disposal facility. This alternative also includes continued federal ownership of the land to control future land use. The following actions would occur:

- Removal and Treatment of Standing Water - Waste Pits 5 and 6 and the Clearwell have standing water requiring treatment by a wastewater treatment facility. The effluent from this facility will be discharged to the Great Miami River and will meet all surface water PRGs and ARARs.

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- Waste Removal and Segregation - Pit wastes and soil will be mechanically or hydraulically removed to attain risk-based PRGs and ARARs. Waste segregation technologies will be employed to facilitate waste handling, treatment, packaging, and disposal.

- Waste Treatment - Excavated waste materials will be processed before treatment. Stable waste materials such as concrete construction rubble and debris will be crushed, shredded, and sent directly for disposal. Pit waste will be dried and transported. Soil will be removed down to 3 ft below the pit liners, treated, and disposed along with the pit waste material. Pit waste, caps, and liners will be excavated and transported to a controlled stockpile where the waste streams can be blended and directed into a shredder which feeds the dryers. The dried waste will be transferred to an operational storage silo above the rail siding. The rail siding will load the rail cars, which will transport the treated waste to a commercial disposal facility in Clive, Utah (see Attachment I.II for a description of the representative commercial facility). The top 6 inches (in) of soil throughout the entire area of Operable Unit 1 will be removed, contained, and turned over to Operable Unit 5 for treatment and final disposition. Clean soil will be used as backfill to reestablish grades and promote proper runoff and drainage control. A cover system consisting of a vegetative layer, a drainage layer, and a dried composite infiltration barrier (synthetic and natural materials) would then be used to complete the seal of the waste pit area.

- Capping - The waste pit area will be backfilled with clean soil and graded before installation of a multimedia cap. The floodplain will be regraded to the original elevation. Any displacement of bank material in Paddys Run would be restructured and returned to its original slope.

- Runoff/Run-on Control - Runoff control features would remove storm water from the operable unit area, and run-on control features would direct storm water away from the closed facility. Surface water would be routed through the waste pit area storm water runoff control system and pumped to the advanced wastewater treatment (AWWT) facility for treatment. Control can be accomplished by using site contour grading, vegetation, diversion and collection ditches, and various physical devices including silt traps and sedimentation basins.

I.2.2 OPERABLE UNIT 2

Operable Unit 2 includes the following waste units: the solid waste landfill, the lime sludge ponds, an inactive flyash pile, an active flyash pile, and the South Field, an area located between and adjacent to the flyash areas (Figure I.2-2). The contents of the waste units are described below. A detailed description of the nature and extent of contamination associated with Operable Unit 2 is provided in the Operable Unit 2 RI Report (DOE 1994c).

- Solid Waste Landfill - located on a 1.5-acre tract at the northeast corner of the waste storage area and northwest of the former production area. The solid waste landfill was used through early 1986 for the disposal of cafeteria wastes, rubbish, and other wastes from nonprocess areas. Materials that reportedly have been disposed of at the landfill include: nonburnable, nonradioactive solid wastes generated on site; nonradioactive, construction-related rubble; nonradioactive asbestos (double-bagged and bulk quantities); medical wastes; radioactively contaminated construction rubble; and radioactively contaminated soils used to cover exposed wastes.

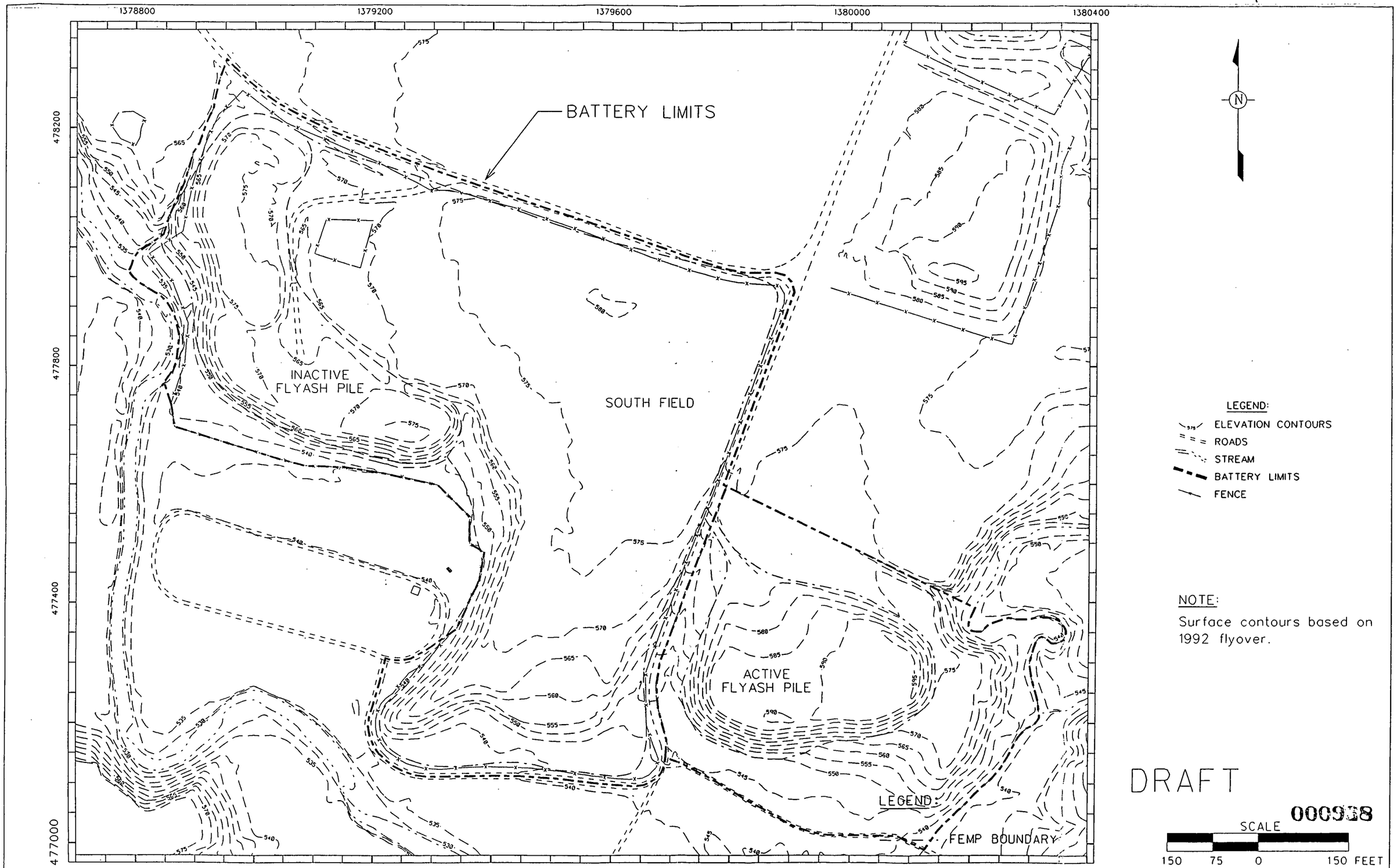

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FIGURE I.2-2. OPERABLE UNIT 2
FLYASH / SOUTH FIELD STUDY AREA

- Lime Sludge Ponds - consist of two ponds, north and south. The north pond is an active, unlined pond located southeast of the waste storage area with approximate dimensions of 125 ft by 225 ft by 5.3 ft deep. This pond is approximately 90 percent full, with a freeboard depth of 2 ft, and is partially covered with vegetation. Standing water that accumulates in the north pond is periodically pumped from the pond to the general sump. Spent lime sludges (primarily lime-alum and boiler plant blowdown) from the FEMP site water treatment plant operations have been conveyed to this active pond. Records do not indicate the routing of any hazardous chemicals or radioactive materials to this pond.

- South Lime Sludge Pond - is an inactive, dry, unlined pond located directly south of the north pond with approximate dimensions of 125 feet by 225 feet by 11.2 feet deep. This pond is retired and overgrown with vegetation. The use of this pond was similar to that of the north pond. Records again do not indicate the routing of any hazardous chemicals or radioactive materials to this pond.

- Active Flyash Pile - formerly received flyash from the coal-fired boiler plant at the FEMP site. This disposal area is located east of the running track and on the east side of the south construction road (Figure I.2-2). The active flyash pile is a roughly hexagonal area of approximately 87,120 square feet (ft^2) with a maximum height of 40 ft. The storm sewer outfall ditch runs along the southeast side of the area.

- Inactive Flyash Pile - located approximately 3000 ft south/southeast of the waste storage area, northwest of the active flyash pile, and west of the South Field. The inactive flyash pile, which is no longer used, covers approximately 130,680 ft^2 and is sparsely covered with soil and vegetation.

- South Field - located between the inactive and active flyash piles where construction rubble was dumped on the surface of the glacial overburden. The thickness of the fill increases at the western and southern edges of the area to approximately 20 ft because material was dumped down the natural slope of an old meander scar. A review of the shallow trenches through the fill indicates that the material is predominantly soil with some rock and concrete and only occasional pieces of wood. The construction rubble deposited in the South Field contained low levels of radioactive materials. Results of trenching activities indicate that the buried materials are within the top 4 feet of soil.

Data gathered in Operable Unit 2 indicate that the areas hold large volumes of solid waste into which small volumes of radiological and/or chemical wastes may have been co-disposed. A review of the RI/FS sampling data for the active and inactive flyash piles and the South Field indicates concentrations of uranium-238 in all media (DOE 1994c).

I.2.2.1 Preferred Alternative for Operable Unit 2

Contaminated material with concentrations above the expanded trespasser and on-property resident farmer cleanup levels would be excavated and segregated according to radiological contamination. The contaminated material would be placed in an on-site disposal cell in the southeast corner of the FEMP site. Any firing range soil that fails the Resource Conservation and Recovery Act (RCRA) toxicity characteristic leaching procedure (TCLP) test would be managed as a RCRA hazardous waste and disposed of at an off-site mixed waste disposal facility. Water would be collected and pumped to a treatment facility, as necessary. Institutional controls would include physical barriers and groundwater monitoring.

I.2.3 OPERABLE UNIT 3

Operable Unit 3 includes the former production area and all above-ground and below-ground production-associated facilities and equipment, encompassing structures, utilities, drums, tanks, solid waste, waste, product, thorium, effluent lines, wastewater treatment and fire training facilities, scrap metal piles, feedstock, and coal pile.

The production of uranium metal products at the FEMP site involved a series of chemical and metallurgical conversions that occurred in nine specialized plants within Operable Unit 3. A number of other buildings housed support operations. Each of these facilities had a distinct purpose, resulting in important differences in the process operations, chemical forms, and types of individual conveyance, storage, and containment units associated with the respective facilities. The potential contaminants resulting from production activities are listed in Table I.2-1. Solid waste materials associated with uranium metals production are presently stored on property in steel drums, awaiting further processing or off-property disposal at approved facilities. These wastes include oils, sludges, contaminated combustibles, filter cake, off-specification uranium or thorium tetrafluoride, and reject uranium trioxide. The drums sit on various pads or in warehouses and are inspected weekly. Contents of deteriorated drums are repackaged. Other drummed wastes on contained surfaces include spent degreasing solvents and material contaminated with polychlorinated biphenyls (PCBs). Estimated volumes of potentially contaminated materials are listed by component in Table I.2-2.

I.2.3.1 Leading Remedial Alternative for Operable Unit 3

The LRA for Operable Unit 3 involves the removal, treatment/ decontamination, and disposal of contaminated buildings and structures to reduce the potential for contaminant migration. Decontamination and treatment residues would require further treatment and disposal. Contaminated materials will be disposed of in an on-property, engineered above-ground disposal facility, and clean materials will be free released for reuse or recycling. The selection of this leading remedial alternative is based on limited characterization and engineering study data and may change. This alternative also includes continued federal ownership of the land to control future land use.

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TABLE I.2-1

OPERABLE UNIT 3 RI/FS ANALYTE LIST

Radionuclides
Isotopic uranium
Isotopic thorium
Isotopic plutonium and 241
Radium-226 and 228
Neptunium-237
Americium-241
Cesium-137
Strontium-90
Lead-210
Polonium-210
Technetium-99
Alpha/Beta Screening

TAL Organics
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc
Cyanide[a]

TCL Semivolatile Organics
1,2-Dichlorobenzene
1,2,4-Trichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
2-Chloronapthalene
2-Chlorophenol

TCL Semivolatile Organics (Continued)
2-Methylnaphthalene
2-Methylphenol
2-Nitroanilene
2-Nitrophenol
2,2-Oxybis-(1-chloroprane)
2,4-Dichlorophenol
2,4-Dimethylphenol
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
2,6-Dinitrotoluene
3-Nitroaniline
3,3-Dichlorobenzidine
4-Bromophenyl-phenyl ether
4-Chloro-3-methylphenol
4-Chloroaniline
4-Chlorophenyl-phenyl ether
4-Methylphenol
4-Nitroaniline
4-Nitrophenol
4,6-Dinitro-2-methylphenol
Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
bis(2-Chloroethyl) ether
bis(2-Chloroethoxyl) methane
bis(2-Ethylhexyl)phthalate
Butylbenzylphthalate
Carbazole
Chrysene
Dibenzofuran
Dibenzo(a,h)anthracene
Diethylphthalate
Dimethylphthalate
Di-n-butylphthalate
Di-n-octylphthalate
Fluoranthene
Fluorene
Hexachlorobenzene

TCL Semivolatile Organics (Continued)
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Ideno(1,2,3-cd)pyrene
Isophorone
Napthalene
Nitrobenzene
N-Nitroso-di-n-dipropylanine
N-Nitrosodiphenylamine
Pentachlorophenol
Phenanthrene

TCL PCBs
Phenol
Pyrene
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

TCL Volatile Organics
1,1-Dichloroethane
1,1-Dichloroethene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
1,1,2,2-Tetrachloroethane
1,2-Dichloroethane
1,2-Dichloroethene (total)
1,2-Dichloropropane
2-Butanone
2-Hexanone
4-Methyl-2-pentanone
Acetone
Benzene
Bromodichloromethane
Bromoform
Bromomethane
Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Chloroethane

TCL Volatile Organics (Continued)
Chloroform
Chloromethane
cis-1,3-Dichloropropene
Dibromochloromethane
Ethyl benzene
Methylene chloride
Styrene
Tetrachloroethene
Toluene
Total xylenes
trans-1,3-Dichloropropene
Trichloroethene
Vinyl chloride

TCLP Metals
Arsenic
Barium
Cadmium
Chromium
Lead
Mercury
Selenium

TCLP Semivolatile Organics
Silver
1,4-Dichlorobenzene
2,4-Dinitrotoluene
Hexachlorobenzene
Hexachloroethane
Hexachloro-1,3-butadiene
Nitrobenzene
Pentachlorophenol
Pyridine
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
o-Cresol
m-Cresol
p-Cresol

TCLP Volatile Organics
Benzene
Carbon tetrachloride
Chlorobenzene
Chloroform
2-Butanone

TABLE I.2-1 (Continued)

TCLP Volatile Organics (Continued)
1,2-Dichloroethane
1,1-Dichloroethylene
Tetrachloroethylene
Trichloroethylene
Vinyl chloride

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TABLE I.2-2

ESTIMATED VOLUMES OF OPERABLE UNIT 3 COMPONENTS

Material Category	Volume (ft^3)
Concrete	3,307,087
Accessible metals	83,663
Inaccessible metals	151,929
Process related metals	2,157,416
Painted light gauge metals	22,118
Nonregulated asbestos containing material	55,969
Regulated asbestos containing material	12,323
Miscellaneous	185,936
Total	5,976,441

The following processes would occur:

- Removal - Buildings and structures will be mechanically removed in a health protective fashion and in compliance with ARARs. Waste segregation technologies will be employed to facilitate waste handling, treatment, packaging, and disposition/disposal. Limited in-place decontamination is anticipated for all materials exhibiting gross removable contamination in order to reduce worker exposures and minimize off-property release during demolition/dismantlement. Soil will be removed using mechanical equipment and processed as described in the Operable Unit 5 representative alternative (Section I.2.5.1). Equipment, drums, waste, and product will be removed, treated, and/or packaged to meet risk-based PRGs and ARARs.

- Waste Treatment/Decontamination - Treatment options for containerized waste and bulk soil materials include the application of a wide range of technologies commensurate with the large quantities and types of waste and product materials in Operable Unit 3. Treatment options for containerized waste and bulk material include soil washing, cement-based stabilization, and vitrification. Equipment and building materials will be decontaminated, employing a range of available technologies including dry concrete scabbling, acid washing, and grit blasting. Soil will be treated as described in the Operable Unit 5 representative alternative. Ongoing treatability programs for the other four FEMP site operable units may provide important information pertinent to a number of the envisioned Operable Unit 3 waste types. Additional treatability studies are envisioned to support Operable Unit 3 to demonstrate the effectiveness of specific treatment and decontamination options.

- On-Property Disposal - Following treatment, volume reduction, and/or packaging, the resultant stable waste will be transferred from a temporary holding area to an on-property disposal facility at the FEMP site. The disposal facility would include a series of above-grade reinforced concrete vaults, which will be underlain by a leachate collection and detection system and covered by a multimedia cap.

- Free Release/Recycle - Decontamination will be employed to the extent practical to maximize reuse and recycling of materials and minimize the requirement for disposal. Materials meeting free release criteria of DOE Order 5400.5 may be distributed for recycling or reuse to commercial vendors or disposed of at public landfills. Some materials may be released to other DOE facilities for controlled recycling and reuse.

I.2.4 OPERABLE UNIT 4

Waste units in Operable Unit 4 consist of two earthen-bermed concrete silos (Silos 1 and 2) containing K-65 residues (high-specific-activity radium-bearing residues resulting from the pitchblende refining process), one concrete silo containing metal oxides (Silo 3), and one unused concrete silo (Silo 4). All the silos are located south of the waste pit area (Figure I.2-1). The domed waste storage silos measure 80 ft in diameter, 36 ft high to the center of the silo dome, and 27 ft to the top of the vertical walls. The walls are 8 inch thick concrete as are the outer part of the domes, which taper to 4 in in thickness at the center. Silos 1 and 2 are surrounded by an earthen berm to a height of approximately 26 ft, while Silos 3 and 4 are freestanding.

Silos 1 and 2 received radium-bearing residues, formed as by-products of uranium ore processing, from 1952 to 1958. Waste raffinates were pumped into the silos where the solids would settle. The free liquid was decanted through a series of valves placed at various levels along the height of the silo walls. Settling and decanting continued until the silos were filled to approximately 4 ft below the top of the vertical walls. Table I.2-5 details the volumes and types of wastes associated with Operable Unit 4.

Corrective actions have been performed to maintain the integrity of Silos 1 and 2. These included repairing the walls, constructing a berm on a 1.5 to 1 slope (mid-1960s), and enlarging the berm to a 3 to 1 slope in the early 1980s. In 1985, a structural assessment was performed which revealed that the walls and base slab were structurally stable and could function as a containment of dry solids for a period of 10 to 15 years. However, the center 20-ft section of the dome was determined to be structurally unsound for a load greater than the existing static load. Remedial actions taken since 1985 include placement of protective covers constructed of steel and plywood over the center portion of each silo dome. A 3 in. layer of rigid polyethylene foam, topped by a 45-mil waterproof, ultraviolet-resistant, urethane-finish coating, was placed over each silo dome in 1987 to provide weather protection and insulation. A radon treatment system was implemented for this project to reduce radiation exposure to the workers during the installation process. In 1991, a layer of bentonite

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clay was inserted over the residues in Silos 1 and 2 to reduce radon levels in the silos and to provide protection in the event of silo dome collapse (this was done under a removal action).

Silos 3 and 4 were constructed in 1952 and were designed to receive dry materials only. Waste raffinate slurries from refinery operations were dewatered in an evaporator and spray calcined to produce a dry waste form for storage in the silo. The waste was blown in under pressure to fill Silo 3. Silo 4 was never used and, except for rainwater infiltration, remains empty.

I.2.4.1 Preferred Alternative for Operable Unit 4

There are three preferred alternatives for the remediation of Operable Unit 4. Two of the preferred alternatives, for the contents of Silos 1 and 2 and for Silo 3, involve the removal of the silo contents, stabilization by vitrification, and off-site disposal at the Nevada Test Site (NTS). In the third alternative, the silo structures (including Silo 4), berms, subsoil beneath Silos 1 and 2, decant sump tank, process piping, and process piping trenches would be removed, decontaminated, and disposed in an on-property disposal facility. Additional details on these alternatives are provided in Section 4.0 of the FS Report for Operable Unit 4 (DOE 1994b).

TABLE I.2-3

OPERABLE UNIT 4 WASTES

Component	Volume (yd^3)(m^3)		
	Silo 1	Silo 2	Silo 3
Bentonite/Grout Cover	465/356	411/314	NA[a]
K-65 Residues	4291/3281	3720/2844	NA
Calcine	NA	NA	5200/3976
Structures	460/352	460/352	460/352
Material Below Silos and Berms[b]	230/176	60/46	500/382
Contaminated Soil	30,000[c]/4664	NA	NA
Total[d]	5446/4164	4651/3556	6160/4710

[a] NA = Not Applicable.
[b] Includes gravel, asphalt, clay, pipes, and decant sump tank.
[c] Total for Silos 1 and 2.
[d] Does not include contaminated soil.

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I.2.5 OPERABLE UNIT 5

The components of Operable Unit 5 include groundwater, perched water, surface water, soil, sediment, flora, and fauna and are described in detail in the SWCR (DOE 1993). Estimates of quantities of groundwater and soil requiring remediation are provided in this FS Report.

I.2.5.1 Representative Alternative for Operable Unit 5

The representative alternative for Operable Unit 5 involves the extraction of contaminated groundwater, treatment at an on-property facility, and discharge of the treated effluent to the Great Miami River through the newly constructed effluent line. The representative alternative also involves the excavation of contaminated sediment/soil necessary to meet risk-based PRLs and ARARs, and transport of soil/sediment to an on-property engineered disposal facility. This alternative also assumes continued federal ownership of the land to control future land use. The following processes would occur:

- Groundwater Extraction - Five recovery wells, installed in the regional aquifer as part of the South Plume removal action, will be supplemented with several additional wells. Each well is estimated to produce an average flow rate of 650 gallons per minute (gpm). Groundwater extraction will continue until risk-based PRGs and ARARs for the regional aquifer are met.

  Perched groundwater will be extracted using french drains, a wellpoint system, and extraction wells. Perched groundwater extraction will continue until risk-based PRGs and ARARs for perched groundwater are met.

- Groundwater Treatment - Groundwater treatment will include a carbon adsorption pretreatment step, followed by precipitation for metals removal, ion exchange for uranium removal, and sludge dewatering. The system may be designed to process up to 8000 gpm, reducing contaminant concentrations to levels necessary to meet risk-based PRGs and ARARs. The treated water will be discharged to the Great Miami River. The sludge generated by the treatment system will be stabilized as necessary and disposed of in an on-property disposal facility.

- Soil Removal - Soil will be excavated using traditional heavy construction equipment and techniques. Some deviations from standard excavation techniques may be necessary for excavation around and under facilities that may remain after Operable Unit 3 remediation. Soil in the contaminated zones will be excavated to meet risk-based PRGs and ARARs. The excavated soil that contains constituents below the remediation goals (based upon analysis) will be separated and used as backfill.

- On-Property Disposal - Following treatment, volume reduction, and packaging, the resultant stable waste will be transferred from a temporary holding area to an on-property disposal facility. The disposal facility is envisioned to include a series of above-ground reinforced concrete vaults, which will be underlain by a leachate collection and detection system and covered by a multimedia cap. It is estimated that approximately 13,800,000 yd^3 will be disposed of on property.

- Off-Property Disposal - Waste/soil which does not meet the waste acceptance criteria for the on-property disposal facility will be transported via truck to an off-property disposal site. It is estimated that approximately 2,840,000 yd^3 of material will be transported off property for disposal.

I.3.0 CUMULATIVE IMPACTS OF PROPOSED ON-PROPERTY ACTIONS

Current scheduling indicates that all of the operable units have potential for concurrent implementation during some portion of the remediation activities (Figure I.3-1). A discussion of the more significant environmental cumulative impacts due to concurrent implementation of remedial activities follows.

I.3.1 SOIL AND GEOLOGY

The mechanical and/or hydraulic removal of pit wastes, soil, buildings, and other structures from the former production area poses a potential short-term threat of releases through subsurface soil to groundwater. Adverse impacts could result if there is a breach of a pit liner during the removal process or if loose contamination is released from the structures. If contaminants remain on the ground surface for extended periods of time, infiltration of rainwater or storm water runoff could cause migration of the contaminants into the subsurface soil. However, appropriate excavation techniques and controls such as routine covering of excavated areas will minimize the potential for these impacts.

Removal of wastes from Silos 1, 2, and 3 would temporarily disturb approximately 8.0 acres of soil. Disturbed areas would be regraded and returned to their previous elevations following remediation. Construction of a disposal facility for silo structures and berm soil would result in the permanent disturbance of approximately 11.6 acres of soil, approximately 1.0 percent of the land area of the FEMP site. No impacts are anticipated on the regional geology of the area as a result of operable unit remedial activities.

The preferred alternative for Operable Unit 1 would result in the temporary disturbance of approximately 36.4 acres of land due to the excavation of the waste pits and associated soil. However, these areas would be regraded and evaluated to promote positive drainage. Furthermore, the preferred alternative for Operable Unit 1 does not involve on-property disposal, thereby resulting in no long-term impacts to soil and geology.

The preferred alternative for Operable Unit 2 involves on-property disposal for all five waste units comprising Operable Unit 2. This would result in temporary impact to approximately 75 acres and the permanent commitment of approximately 23 acres for on-property disposal. The construction of a storm water control channel associated with the disposal cell would result in approximately 35 acres of permanent land commitment.

When the preferred alternatives selected in the Operable Units 1, 2, and 4 FS reports are combined with the leading remedial alternative for Operable Unit 3 and the representative alternative for

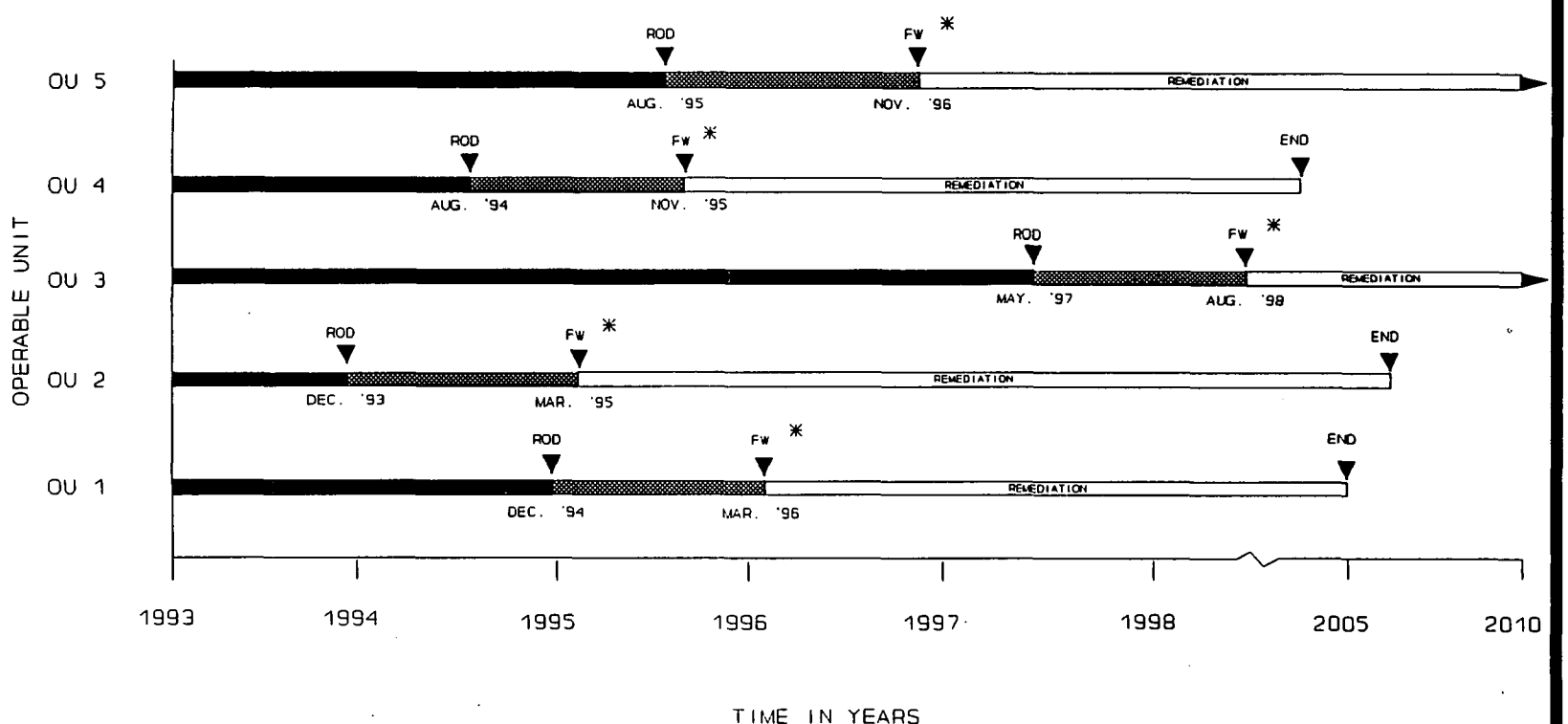

FIGURE 1.3-1. CURRENT SCHEDULE FOR REMEDIATION

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Operable Unit 5, it is likely that approximately 517.2 acres will be disturbed during remediation, with 208 acres permanently committed to disposal.

Adverse impacts on surface soil could occur during waste removal, segregation, and treatment. There is the potential for spills to occur during the handling and packaging of waste as well as during transport to the treatment facility. Spills would be expected to affect only localized areas, and surface soil contaminated by a spill could be excavated and disposed of with the waste material. Therefore, impacts on surface soil from spills would likely be minor. Appropriate spill prevention and response procedures will ensure impacts related to spills are negligible.

The removal of contaminated structures from the former production area, along with waste treatment and decontamination, should have beneficial long-term effects on both surface and subsurface soil due to the removal of contaminant sources. Pumping and treatment of the contaminated perched and regional groundwater should stop contaminant migration in the subsurface soil.

I.3.2 WATER QUALITY AND HYDROLOGY

Adverse impacts to both the perched groundwater and the regional aquifer would not be increased by concurrent remedial activities. The possibility of contaminant migration to the aquifer exists during any remedial activity, whether the activities are performed individually or concurrently. The rate at which contaminants are supplied to the regional aquifer may be increased with concurrent remediation activities, but the overall contaminant load would remain the same. The EPA proposed drinking water standard for uranium in drinking water is 20 parts per billion (ppb) (EPA 1986).

Groundwater monitoring will continue throughout remedial actions and upon completion of remedial actions to ensure that areas exceeding the standards are identified and appropriate response actions are implemented. Long-term groundwater quality should improve through implementation of the preferred and leading remedial alternatives since FEMP wastes will be eliminated and/or isolated from rainwater and storm water runoff, preventing the potential infiltration of these contaminants to perched groundwater and the regional aquifer. Any hazardous waste disposal facility would comply with the requirements specified in the facility permit for the uppermost aquifer underlying the waste management area beyond the point of compliance. The concentration of chemicals in groundwater should not exceed background levels of the listed maximum concentration of the constituent for groundwater protection (10 Code of Federal Regulations [CFR] 264.94).

The findings of the Operable Unit 5 Comprehensive Response Action Risk Evaluation (CRARE) (Appendix H) identified the consumption of drinking water obtained from wells drilled into the groundwater as the greatest pathway of exposure to a hypothetical on-property resident farmer.

Groundwater modeling in the CRARE predicted that the highest cancer risk in this pathway would be associated with arsenic leaching from site-wide soil. However, the carcinogenic risk levels associated with the groundwater pathway under the Case 7 land use scenario are within the target risk range of 10^{-6} to 10^{-4} to the undeveloped park users and off-property resident farmer receptors.

Groundwater monitoring will continue throughout and upon completion of remedial actions to ensure that areas exceeding the standards are identified and appropriate response actions are implemented.

I.3.2.1 Surface Water

The simultaneous implementation of remedial alternatives would potentially increase surface water quality impacts over those which would normally be expected from implementation of a single project. Impacts to surface water quality in Paddys Run could result during removal of Operable Unit 2 waste units; during removal, treatment, and on-property disposal of Operable Units 3 and 5 wastes; and during the removal, decontamination, and on-property disposal of Silos 1, 2, and 3 structures, berms, and soil in Operable Unit 4. Short-term impacts resulting from these activities may include contaminated runoff entering Paddys Run; erosion of exposed wastes and the subsequent influx of contaminated soil into the stream during waste removal; and increased stream turbidity resulting from excavation of contaminated sediment and relocation of portions of the stream. However, appropriate engineering controls would be implemented to control runoff and other impacts to Paddys Run. The use of silt fences, straw bales, and other drainage and erosion control measures would be particularly critical as part of the remedial activity for the inactive flyash pile (Operable Unit 2) and silo remediation (Operable Unit 4).

Over the long term, surface water quality in Paddys Run should improve since FEMP wastes will be isolated from rainwater and storm water runoff, thus eliminating the potential migration of contaminated material into Paddys Run. No cumulative impacts on the Great Miami River are anticipated from the simultaneous implementation of the remedial alternatives. All effluents produced by the remedial alternatives will be treated to comply with FEMP NPDES permit limits and conditions before discharge to the Great Miami River.

I.3.3 AIR QUALITY

Cumulative air quality impacts will be based on projected emissions from the remedial alternatives for each of the operable units at the FEMP site. The emissions of primary short- and long-term concern with respect to ambient air involve the reentrainment of radiologically contaminated fugitive dust and the volatilization of toxic chemicals.

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Remedial alternatives that involve substantial waste handling, excavation, ground clearing, demolition, cut-and-fill operations, loading/unloading trucks, or heavy equipment traffic have the potential to generate radiologically contaminated dust and other waste constituents. During these activities, periods of turbulent wind conditions can resuspend particles of disturbed surface materials (e.g., contaminated soil) in ambient air and transport them to on- and/or off-property receptors. The amount of dust resuspended depends on wind speed and other site conditions such as soil moisture, particle size, and vegetative cover.

The potential for long-term residual risks associated with the FEMP site in a postremediation condition is evaluated in the CRARE, Appendix H.

Additional potential airborne pollutants associated with remedial activities at the FEMP site include inorganic constituents, volatile organics, semivolatiles, PCBs, dichlorodiphenyl trichloroethane (DDT), herbicides, radionuclides, and radon. Emissions of these pollutants could result from the removal and handling of volatile or semivolatile wastes, waste segregation activities, and vitrification processes.

In the past, radon has been a significant portion of the annual dose to the public adjacent to the FEMP site. Until remedial activities are complete, DOE Order 5400.5 regulates radon concentrations in the atmosphere above facility surfaces or openings at and adjacent to the FEMP. When added to background levels, the concentrations mandated by DOE Order 5400.5 must not exceed an annual average concentration of 30 picocuries per liter (pCi/L) at the facility and 3 pCi/L at or above any location outside the facility. Once remedial activities have been completed, the National Emissions Standards for Hazardous Air Pollutants (NESHAP) Subpart Q standard (40 CFR 61 Subpart Q) of 20 $pCi/m^2/s$ for radon-222 will be applied to site storage and disposal areas for radon-producing wastes. An active monitoring system has been in place at the FEMP site since the early 1980s. As a point of comparison, the average site boundary total radon concentration of 0.57 pCi/L in 1992 was about 29 percent of the average indoor radon concentration (2.0 pCi/L) for homes in the Cincinnati area. Monitoring will continue throughout the remedial activities and upon completion of remedial activities (as appropriate) to ensure that radon levels remain in compliance with all applicable regulations.

Guidelines for concentrations of radionuclides other than radon-222 are also established by DOE Order 5400.5. These concentrations, referred to as derived concentration guidelines (DCGs), are concentrations of radionuclides that, under conditions of continuous exposure for one year by one exposure mode, would result in a dose of 100 rem. In addition to the DCGs, radiologic emissions to the ambient air from the FEMP site will also be subject to the NESHAP Subpart H standard

(40 CFR Part 61 Subpart H), which stipulates that radiological emissions from the site cannot exceed those amounts that might cause any member of the public to receive an annual effective dose equivalent (EDE) of 10 rem per year. Monitoring of the air pathway for radionuclides during the FEMP site remedial activities will continue to ensure that emission levels do not exceed applicable DCGs or the NESHAP Subpart H standard.

The impacts associated with the generation of fugitive dust and the volatilization of toxic chemicals tend to be short term. Cumulative air quality impacts that would occur during phases of remedial activity at the FEMP site would include pollutants generated off property as well as those generated on property. Although there are no major sources of pollutants in the vicinity of the FEMP site, there would be an increase of transportation-related particulates generated off property by the large number of trucks necessary to supply construction materials for the disposal facility. In addition to particulates generated on property by disposal facility construction, filling, soil excavation, and closure, the cumulative air quality impact would also depend on: 1) the remedial alternatives chosen, 2) the remediation schedule (e.g., the extent of simultaneous remedial activities across the FEMP site), 3) the mitigating measures or controls chosen, and 4) their effectiveness. Typical control methods for various remedial activities and qualitative evaluations of their effectiveness, advantages, and disadvantages are included in the Operable Unit 4 FS Report, Appendix I, Attachment I.I, Table I.I-3 (DOE 1994b).

I.3.4 BIOTIC RESOURCES

Cumulative impacts on vegetation could result from short- and long-term removal and disturbance of habitat associated with remediation of contaminated soils and waste units; construction of staging areas, support facilities, and the disposal facility; and general physical disturbance of soil. The removal of Operable Unit 2 waste areas would result in the permanent disruption of approximately 15.8 acres of introduced grassland, managed field, and old field habitats. Construction of on-property disposal facilities for Operable Units 3, 4, and 5 could also disturb introduced grasslands, old field, and mid-successional and riparian woodland habitats. Construction of on-property disposal facility(s) for Operable Units 3, 4, and 5 would result in a total loss of approximately 196 acres. Construction of support facilities would have a similar impact, although restoration may be possible once wastes are removed from the FEMP site.

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Concurrent implementation of remediation activities could have impacts on wildlife primarily through the short- and long-term removal and disturbance of habitat as described above, with correlated reductions in local wildlife populations. Cumulative impacts on wildlife would differ from the impacts of these same preferred or leading remedial alternatives considered separately. For example, if remedial activities were spread out over time, adjacent undisturbed areas could provide refuges for displaced wildlife. These "safe" areas would not be available if activities are conducted simultaneously. Cumulative project-related noise and increased levels of human activity could disrupt nearby wildlife. However, it is not expected that wildlife will be permanently displaced from the site.

Cumulative impacts on aquatic organisms from remedial actions involve the potential contamination of Paddys Run, the Great Miami River, and various drainageways, floodplains and wetland areas. Potentially affected aquatic organisms include fish, invertebrates, amphibians, reptiles, and semiaquatic species such as muskrats. Loss of habitat or contaminant exposure could also lead to a reduction in species biodiversity.

Levels of contaminants could increase in Paddys Run and wetland drainage areas from soil erosion and runoff during concurrent waste removal, stabilization, and isolation activities. Additionally, disruption of aquatic habitat in these areas from the excavation of contaminated sediments for Operable Unit 5 could adversely affect organisms residing in this area. Small affected areas in Paddys Run and the wetland drainages resulting from isolated remedial actions would probably recover quickly, but recovery from simultaneous impacts over a larger area would likely require a much longer time to restabilize. Adverse cumulative impacts on aquatic organisms could be substantially mitigated by diversion and collection of runoff and by performing removal activities when flow in Paddys Run and the storm sewer outfall ditch is low or nonexistent.

Waste removal, stabilization, and isolation activities conducted for Operable Unit 1, combined with the concurrent siting of an on-site disposal facility in this area of the site, would likely result in short-term adverse cumulative impacts on the organisms in the wetland drainages in this area. Long-term, negative effects on aquatic organisms would be minimized if the areas were revegetated to prevent erosion after completion of the activities. Of particular concern is the 26-acre tract of forested wetlands in the northern portion of the FEMP site. This area would be avoided as much as possible. The cumulative effects would be beneficial in the long term by reducing or eliminating exposure to wastes.

I.3.4.1 Threatened and Endangered Species

Cumulative impacts on threatened and endangered species potentially include the potential loss of habitat, disruption of breeding activities, and loss of individuals. Disturbances in the riparian corridor along Paddys Run could result in impacts to the Sloan's crayfish (*Orconectes sloanii*) and habitat of

the Indiana bat (*Myotis sodalis*). The use of relocation and erosion control measures will be employed to minimize short-term adverse impacts on Sloan's crayfish. In the long term, the cumulative impacts of FEMP site remedial activities will be beneficial due to the prevention of releases of contaminants into the environment.

I.3.5 WETLANDS AND FLOODPLAINS

A site-wide delineation was conducted in February 1993 in accordance with the 1987 Army Corps of Engineers Wetlands Delineation Manual and approved on August 12, 1993. The purpose of the delineation was to determine the extent of jurisdictional wetlands and waters of the United States at the FEMP site and to avoid or minimize impacts to these resources during future activities. Results from the site-wide delineation indicate a total of 35.9 acres of jurisdictional freshwater wetlands on the FEMP site. Wetland impacts as a result of remedial activities would be minimized by implementing best management practices during and following remediation. Proper notification and mitigative measures would be executed if impacts are expected to occur.

Cumulative wetland impacts may also arise from the implementation of the remedial alternatives, particularly in the forested wetland in the northern part of the site and the various emergent wetlands associated with site drainage ditches. The greatest wetland impact could result from siting a disposal facility and from excavation during waste removal and construction activities. Proposed DOE actions in these wetlands would first be evaluated for potential adverse effects to the wetlands (10 CFR 1022), and consideration would be given to natural and beneficial values provided by the wetlands when considering mitigation alternatives to offset the impacts. Appropriate federal register notifications as required under 10 CFR 1022 would take place for all actions affecting wetlands.

Floodplains within the FEMP property are confined to the north-south corridor containing Paddys Run. Outside the boundaries of the FEMP, the 100- and 500-year floodplain of the Great Miami River extends west of the big bend to an elevation near the eastern boundary of the facility. The 100- and 500-year floodplain of the river also extends northward along Paddys Run from the confluence of the two streams to a point north of the northern boundary of the FEMP. During remediation, some impact to the 100-year and 500-year floodplain of Paddys Run may occur due to excavation activities. In extreme cases, the relocation of Paddys Run and the floodplain may be necessary. During remedial action, engineering controls (e.g., silt fences and berms) will be used to minimize floodplain impacts. In cases where relocation is required, the floodplain will be reestablished to near original condition.

I.3.6 SOCIOECONOMICS AND LAND USE

Overlap in the implementation of remedial activities for the operable units could magnify the impacts resulting from the remediation of a single waste unit or operable unit. The following is a discussion

of potential impacts of concurrent remedial activity at the FEMP site on the local economy, land use, noise levels, transportation systems, and community services.

I.3.6.1 Economic Activity

The maximum number of workers that would be required for implementation of preferred or leading remedial alternatives for each operable unit is expected to be small. Although the scope of work may be large, the work is usually expected to be completed by multiple small crews working over a long period of time. For example, the labor force required to construct the on-property disposal facility is estimated at a maximum of 155 persons per day over the 20-year life span of the project. More specific impacts on the local economy will be estimated as detailed cost estimates are made and will be reported in the Operable Unit 3 FS Report.

Overall levels of employment at the FEMP site are expected to remain relatively consistent throughout the remedial process. Existing on-site workers will be used to the extent possible. However, it is expected that specialized personnel will be brought in during remedial activities to acquire needed skills.

One sector of the local economy that would experience direct impacts resulting from remedial activity at the FEMP site would be wholesale and retail sales, with particular emphasis on the provision of backfill and construction materials such as concrete, aggregate, and lumber. These impacts would be most felt with the initiation of on-property disposal alternatives. For example, construction material requirements for the disposal facility would be substantial (Parsons 1992). Indirect impacts to employment in these sectors would also be likely.

I.3.6.2 Land Use

A number of acres that contain prime agricultural soil are located within the boundaries of the FEMP site; however, this land is not designated as prime farmland. Prime farmland is defined by the proper combination of current cultivation (which is lacking at the FEMP), soil, slope, length of growing season, and rainfall to allow the production of sustained crop yield with the least effort. The construction of an on-property disposal facility would result in an irretrievable loss of some of this soil. However, requirements for land meeting the definition of prime farmland will not be applicable.

I.3.6.3 Noise

Noise is defined as unwanted or undesirable sounds that have an adverse effect on human beings and their environment including land, structures, natural wildlife, and ecological systems (Canter 1977).

The measurements of noise are expressed in a logarithmic ratio of sound pressure referred to as the sound pressure level and are quantified using the term "decibel" (dB). To obtain a representative sound level containing a wide range of frequencies that humans respond to, the "sound pressure level" is A-weighted resulting in the term dBA. Normal human hearing capabilities range from 0 dBA (the threshold of hearing) to 140 dBA (a jet plane on the ground at 20 ft).

With a population density of 917 residents/square mile combined with the presence of industry in the area, land use within a 5 mi radius around the FEMP site could operationally be classified as agricultural/quiet residential. This classification provided by Canter (1977), combined with noise level data recorded by the Westinghouse Environmental Management Company of Ohio in 1991, indicate that the current average background noise level within the 5 mi radius is approximately 50 dBA.

Noise levels at the FEMP site are expected to fluctuate according to the type of activity being conducted. Typical activities would include heavy equipment operation, organization and placement of dismantled building materials, waste treatment operations, general construction traffic (e.g., waste and material shipments), and commuter traffic.

Rather than increasing and decreasing in a linear fashion, noise propagating from a point source changes logarithmically. Consequently, for every doubling of the distance away from the source of the noise, the sound level decreases by 6 DBA. Most remedial activities will take place towards the center of the FEMP site. An activity emitting a sound level of 100 DBA would decrease to 60 DBA once the sound wave reaches a resident one mile away from the sound source. This would result in a 10 dBA sound level above the 50 dBA background sound level at the FEMP site. It is assumed that general construction noise might be heard by the some of the surrounding communities; however, the noise levels for the closest resident would not increase more than 10 to 15 dBA over an eight-hour period. Although no sound barriers would be constructed during remedial activities, noise levels will be reduced through engineering controls. Noise levels for on-site workers will not exceed the 85 dBA (Occupational Safety and Health Act 29 CFR Part 1910.95) standard through the implementation of the site noise conservation program currently enforced at the FEMP site.

I.3.6.4 Transportation

Possibly the greatest environmental impact both on site and to local residents from concurrent implementation of operable unit remediations at the FEMP site is from the increase in traffic flow. Transportation routes off property will be impacted by four categories of shipments: (1) transport of waste for off-site disposal either at the NTS or a commercial disposal facility, (2) bringing backfill and construction materials from off-site regional sources, (3) movement of waste and material within

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site boundaries, and (4) a variety of wastes, hazardous materials, laboratory, and treatability samples which are to be disposed of during CERCLA removal actions. Included are: RCRA wastes, hazardous wastes, mixed waste, low-level waste, PCB-contaminated waste (currently stored on site and awaiting final disposal) and hazardous materials which resulted from past production operations (e.g., low-level residues, high-grade residues, orange oxide [UO_3], green salt [UF_4], uranium derbies, and refinery feedstock currently awaiting final disposition). Facilities that are to receive and ship the waste, hazardous materials, and samples include, but are not limited to, the following: privately owned, licensed treatment and disposal facilities; privately owned laboratories; privately owned nuclear facilities; and federal facilities (e.g., other DOE sites).

Transport of Waste for Off-Site Disposal

Operable Units 1 and 5 are likely to ship waste off property for disposal during concurrent implementation of remedial actions. Operable Unit 1 estimates 638 train shipments in five years, and Operable Unit 5 estimates approximately 833 truck trips over 22 years. These shipments will be completed before beginning work on Operable Units 1 and 5. The maximum monthly increase in truck traffic (Monday through Friday) would be three truck trips/month. Train traffic would increase by approximately 11 trains per month.

Off-property disposal shipments for Operable Units 2 and 4 by rail and Operable Unit 3 by truck would be minimal and would not significantly increase waste shipments.

Backfill from Off-Site Local Sources

Backfill from off-site sources will be required for Operable Units 2, 4, and 5. Present estimates indicate 22,230 truck trips over 9.5 years for Operable Unit 2. Operable Unit 4 estimates are 188 truck trips over six years, and 117,320 truck trips over 22 years are estimated for Operable Unit 5. The maximum daily increase would be approximately 40 truck trips per day transporting backfill to the FEMP site from off-site sources.

I.3.6.5 Community Services

Community services that could be affected by remedial activities include schools, health care facilities, housing, emergency and protective services, and water and wastewater treatment systems. Impacts to these services would primarily arise from relocating large numbers of workers during major activities such as the remediation. Because the employment requirements for FEMP site remediation are not expected to result in a major influx of workers during remedial activity, due in part to the work being spread over time, no long-term impacts on these services are anticipated.

I.3.7 CULTURAL RESOURCES

Any federal activity that may adversely affect a site or structure that is listed in the National Register of Historic Places (NRHP) or is considered eligible for inclusion in the NRHP must undergo rigorous scrutiny to ensure that the adverse effect is avoided. This examination is also necessary to determine potentially significant sites such as uncovered archaeological remains. To ensure that no resources will be affected by remedial activities in the other operable units, an archaeological survey of the property would be performed. The rainbow arch bridge over Paddys Run on Willey Road may be affected by transport of materials to the FEMP site. The Ohio Historic Preservation Office and the Ohio Department of Transportation would be contacted for consultation. Any additional construction proposed beyond the boundaries of the FEMP site would require an archaeological survey and consultation with state and national preservation officials before initiation.

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I.4.0 AGENCIES CONSULTED AND RELATIONSHIP TO OBJECTIVES OF LOCAL, STATE, REGIONAL, AND FEDERAL LAND USE PLANS, POLICIES, AND CONTROLS

During the development of the lead FS/PP-EIS for Operable Unit 4, a number of federal, regional, state, and local organizations were contacted for information or assistance. This information has been referenced herein for the Operable Unit 5 FS/PP-NEPA evaluation. Some of these agencies were also contacted for consultation under 40 CFR 1502.16, which requires a discussion of "possible conflicts with the objectives of state, federal, regional, and local land use plans, policies, and controls" in environmental documents. Agencies were contacted under this provision to determine whether any conflicts would arise as a result of remedial activity at the FEMP site. No agency or organization that was contacted considered future remedial actions at the FEMP site to be in conflict with its land use plans, policies, or controls in the area. The following organizations were contacted:

Federal

- U.S. Environmental Protection Agency
- U.S. Department of the Interior
- U.S. Department of Transportation
- Bureau of Land Management
- U.S. Fish and Wildlife Service
- Federal Emergency Management Agency
- Army Corps of Engineering, Louisville, KY District

State

- Ohio Environmental Protection Agency
- Ohio Department of Natural Resources, Wildlife Division
- Ohio Department of Transportation
- Ohio Department of Natural Resources, Division of Natural Areas and Preserves, Parks Department
  - Soil Conservation Service
  - Ohio Historic Preservation Office
  - Ohio Department of Commerce, Data Users Center
  - Ohio Department of Rehabilitation and Correction

County

- Hamilton County Planning Commission
- Hamilton County Park District
- Hamilton County Engineer
- Hamilton County Cooperative Extension Service
- Butler County Planning Commission
- Butler County Park District
- Butler County Engineer

- Butler County Cooperative Extension Service
- Butler County Treasury Office
- Hamilton County Treasury Office
- Warren County Auditors Office
- Clermont County Accounting Office
- Brown County Auditors Office
- Boone County (Kentucky) Auditors Office
- Gallatin County (Kentucky) Auditors Office
- Kenton County (Kentucky) Treasury Office
- Grant County (Kentucky) Treasury Office
- Campbell County (Kentucky) Payroll Office
- Pendleton County (Kentucky) Auditors Office
- Dearborn County (Indiana) Auditors Office
- Ohio County (Indiana) Treasury Office

Regional

- Ohio-Kentucky-Indiana Regional Council of Governments - A regional planning agency involved in a variety of areas including water resources, solid waste management, population studies, public services management, transportation, and land use in the Greater Cincinnati area.

- Ohio River Valley Sanitation Commission - A group responsible for monitoring and reporting the water quality of the Ohio River and its major tributaries.

- Water Management Association of Ohio - An organization dedicated to supporting the development, conservation, control, protection, and use of Ohio's water resources for beneficial purposes.

- Miami Conservancy District - A water conservation subdistrict responsible for the observation and evaluation of water resources in the area between Hamilton and New Baltimore.

- Miami Purchase Association for Historic Preservation

Local

- Hillside Trust - A nonprofit organization dedicated to promoting the preservation and thoughtful use of the hillsides in the Greater Cincinnati area.
- Hamilton County Prisons
- Great Rivers Council, Girl Scouts of America
- Ross Township Trustees
- Crosby Township Trustees

I.5.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The implementation of the remedial alternatives for Operable Units 1 through 5 will result in the commitment of land, economic resources, and regional raw materials. The alternatives will require a commitment of resources to retain wastes on property. These alternatives could result in the restricted use of the land for thousands of years. The commitment of raw materials, economic resources, and some land is unavoidable for any alternative at the FEMP site. The irretrievable commitment of the site as a permanent waste facility needs to be examined carefully in terms of DOE's future policies in the waste management program.

The following paragraphs will analyze these commitments, using information available at this time. Alternatives for Operable Unit 3 are in preliminary planning stages, and the total resources required for remedial alternatives are not developed. Therefore, the cumulative commitment of resources cannot be completely quantified at this time. The Operable Unit 3 FS report will update and expand this analysis. The purpose of the evaluation of resource commitment is to outline the major issues and tradeoffs to be considered in the final selection of remedial and waste management alternatives for the FEMP site.

Each remedial alternative will require some commitment of land, economic resources, and regional raw materials. The alternatives that require excavation, on-property treatment, and on-property disposal will require the highest commitment of land, economic resources, and regional raw materials. At least 517.2 acres of land would be disturbed during remediation operations. The waste that is removed (with the exception of most Operable Unit 4 and all Operable Unit 1 material) will be placed in an on-property disposal facility, which will require 208 acres of land at the 1050-acre site.

Approximately 208 acres would be irretrievable and committed to the DOE waste management program and DOE ownership as a result of on-property disposal. The remaining 842 acres of site property could be made available for restricted use such as industrial or recreational (developed or undeveloped park).

As part of the commitment of land at the FEMP, the subsequent loss of various types of habitat will likely occur. It is likely that a portion of the acreage committed to on-property disposal will be in the form of wetlands and various habitats. In addition, managed field habitat in the solid waste landfill would be lost as a result of containment activities.

If the FEMP site were to remain a permanent waste facility and part of the DOE waste management program, there would be a commitment to retain most of the wastes stored on property in a stabilized form. Some of the FEMP site will not be returned to its original agricultural condition. The facility will be monitored and the land will be controlled for an indefinite period of time.

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ATTACHMENT I.I

DESCRIPTION OF OFF-SITE DISPOSAL AREAS

I.I.0 DESCRIPTION OF OFF-SITE DISPOSAL AREAS

I.I.1 Nevada Test Site

The selected alternative for the Operable Unit 4 waste material calls for the disposal of wastes at an existing government facility located in an arid western environment. This facility is currently operating and accepting many types of U.S. DOE waste. An Environmental Impact Statement for waste disposal activities at the Nevada Test Site (NTS) is currently in process to satisfy the requirements of the National Environmental Policy Act (NEPA). Several disposal technologies are currently utilized at NTS (e.g., shallow land burial, burial in trenches, and disposal in large-diameter augured shafts). However, only shallow land burial is utilized for low-level waste, and mixed waste is not currently accepted at the facility. Because the facility is located in an area with an arid climate far from any population centers and significant water sources, it offers many advantages from a long-term risk standpoint. An interim on-site storage facility can be a part of this process option if the administrative and regulatory issues for off-site waste disposal have not been resolved at the start of remediation. The wastes could be transported to the facility by truck or rail as discussed elsewhere in this appendix.

Human habitation of the NTS area ranges from as early as 10,000 B.C. to the present. Various aboriginal cultures occupied the NTS area over this extended period, as evidenced by the presence of artifacts at many sites and more substantial deposits of cultural material in several rock shelters. This period of aboriginal occupation was sustained primarily by a hunting and gathering economy based on temporary campsites and shelters. The area was occupied by Paiute Indians at the time of the first known outside contact in 1849 (DOE 1991).

The NTS, operated by the DOE, has been the primary location for testing the nation's nuclear explosive devices, including nuclear weapons, since January 1951. It is located in Nye County, Nevada, with the southeast corner lying about 65 mi northwest of the city of Las Vegas, Nevada. The NTS encompasses about 1350 mi^2, an area larger than the State of Rhode Island. The dimensions of the NTS vary from 28 to 35 mi in width (eastern to western border) and from 40 to 55 mi in length (northern to southern border). The NTS is surrounded on the east, north, and west sides by public access exclusion areas consisting of the Nellis Air Force Base (NAFB) Bombing and Gunnery Range and the Tonopah Test Range. These two areas comprise the NAFB Range Complex, which provides a buffer zone between the test areas and public lands. The combination of the NAFB Range Complex and the NTS is one of the larger unpopulated land area in the United States, comprising some 5470 mi^2. Mercury, Nevada, located at the southern end of the NTS, is the main base camp for worker housing and administrative operations for the site. Area 12 base camp, located at the northern end of the site, is the other major worker housing and operations support facility.

The NTS topography is typical of much of the basin and range physiographic province of Nevada, Arizona, and Utah. North-south-trending mountain ranges are separated by broad, flat-floored, and gently sloped valleys. Elevations range from about 3000 ft above mean sea level (MSL) in the south and east, rising to 6900 ft in the mesa areas towards the northern and western boundaries. The slopes on the upland surfaces are steep and dissected, whereas the slopes on the lower surfaces are gentle and alleviated with rock debris from the adjacent highlands. The principle effect upon the terrain from nuclear testing has been the creation of numerous dish-shaped surface subsidence craters, particularly in Yucca Flat. There are not continuously flowing streams on the NTS. Surface drainages from Yucca Flat and Frenchman Flat are in closed-basin systems, which drain onto the dry lake beds (playas) in each valley. The remaining area of the NTS drains via arroyos and dry streambeds that carry water only during unusually intense or persistent storms. Rainfall or snow melt typically infiltrates quickly into the moisture-deficient soil, or it runs off in normally dry channels, where it evaporates or seeps into permeable sands and gravel. During extreme conditions, flash floods may occur. The northwest portion (Pahute Mesa) of the NTS has integrated channel systems which carry runoff beyond NTS boundaries into the Kawich Valley and Gold Flat on the NAFB Range Complex. The western half and southernmost part of the NTS have channel systems which carry runoff from intense storms towards the southern boundary of the NTS and off site towards the Amargosa Desert (DOE 1991).

In general, the geology consists of three major rock units. These are (1) completely folded and faulted sedimentary rocks of Paleozoic age overlain at many places by (2) volcanic tuffs and lavas of Tertiary age, which (in the valleys) are covered by (3) alluvium of late Tertiary and Quaternary age. The sedimentary rocks of Paleozoic age are many thousands of feet thick and are comprised mainly of carbonate rocks (shale and quartzite). The volcanic rocks are relatively underformed, and dips are generally gentle. The alluvium is derived from erosion of the nearby hills of tertiary and Paleozoic rocks. The volcanic rocks of Tertiary age are predominantly tuffs, which erupted from various volcanic centers and lavas, and are mostly rhyolitic in composition. The aggregate thickness of the volcanic rocks is many thousands feet, but in most places, the total thickness of the section is far less because of erosion or nondeposition. These materials erupted before the collapse of large volcanic centers known as calderas. Alluvial materials fill the intermountain valleys and cover the adjacent slopes. This sediment attains thickness of 2000 to 3000 ft in the central portions of the valleys. The alluvium in Yucca Flat is vertically offset along the prominent north-south-trending Yucca fault.

Depths to groundwater beneath the NTS vary from about 515 ft beneath the Frenchman Flat playa (DOE 1991) in the southern part of NTS to more than 2000 ft beneath part of Pahute Mesa. In the eastern portions of the NTS, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer. The flow in the shallower parts of the groundwater body is

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generally toward major valleys (Yucca and Frenchman) where it deflects downward to join the regional drainage to the southwest in the carbonate aquifer. The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley groundwater basin. Groundwater beneath the eastern part of the NTS is in the Ash Meadows subbasin defined by discharge through evapotranspiration along a spring line in Ash Meadows (south of the NTS). Most of the western NTS is in the Alkali Flat/Furnace Creek Ranch subbasin, which discharges by evapotranspiration at Alkali Flat and by spring discharge near Furnace Creek Ranch. Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley subbasin, discharging by evapotranspiration in the Oasis Valley.

A long-term hydraulic monitoring program was instituted in 1972 to be operated by the EPA under an interagency agreement. Groundwater was monitored on and around the NTS, at eight sites in other states, and at two locations off property in Nevada in 1991 to detect the presence of any radioactivity in the groundwater. No radioactivity was detected in the groundwater sampling network around NTS. The NTS groundwater monitoring network currently utilizes wells that were drilled for water supply or exploratory purposes. Therefore, an extensive program to install groundwater monitoring wells has been implemented. The program will involve the installation of approximately 90 wells on or near NTS.

Precipitation levels at the NTS are low, runoff is intermittent, and the majority of the active testing areas on the NTS drain into closed basins on the site. The NTS mesas receive an average annual precipitation of 9 in., which includes winter snow accumulations. The lower elevations receive approximately 6 in. of precipitation annually, with occasional snow accumulations lasting only a matter of days. Predominating winds are southerly during summer and northerly during winter. The prevailing wind direction during winter months is from north-northeast; during summer months, winds prevail from the south. In Yucca Flat, the average annual wind speed is 7 miles per hour (mi/hr). The prevailing wind direction during the winter months is north-northwest and during summer months is south-southwest. At Mercury, the average annual wind speed is 8 mi/hr, with a prevailing wind direction of northwest during the winter months and southwest during the summer months.

The greater part of the NTS is vegetated by various associations of desert shrubs typical of the Mojave or Great Basin Deserts or the zone of transition desert between these two. There are areas of desert woodland (pinon and juniper) at higher elevations. Even there, typical Great Basin shrubs, principally sagebrush, are a conspicuous component of the vegetation. Although shrubs (or shrubs and small trees) are the dominant forms, herbaceous plants are well represented in the flora and play an important role in supporting animal life.

Extensive floral collection has yielded 711 taxa of vascular plants within or near the boundaries of the NTS (DOE 1991). Associations of creosote brush *(Larrea tridentata)*, which are characteristic of the Mojave Desert, dominate the vegetation mosaic on the dajadas of the southern NTS. Between 4000 and 5000 ft elevations in Yucca Flat, transitional associations are dominated by hopsage/desert thorn *(Grayia spinosa/Lycium andersonii)* associations, while the upper bajadas support *Coleogyne* types. Above 5000 ft, the vegetation mosaic is dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* ssp. *nova*. Above 6000 ft, pinon pine and juniper mix with the sagebrush associations where there is suitable moisture for these trees. No plant species located on the NTS is currently on the federal endangered species list; however, the state of Nevada has placed *Astragalus beatleyae* on its critical species list. Most mammals on the NTS are small and secretive (often nocturnal in habitat), hence not often seen by casual observers; larger mammals include horses, burros, deer, mountain lions, bobcats, coyote, kit foxes, and rabbits. Reptiles include four species of venomous snakes; bird species are mostly migrants or seasonal residents. In terms of distribution or relative abundance, rodents are the most important group of mammals on the NTS. Most nonrodent mammals have been placed in the "protected" classification by the state of Nevada. In 1989, the desert tortoise *(Gopherus agassizii)* was placed on the endangered species list by the U.S. Department of Interior and was relisted as threatened in 1991. Tortoise habitats on the NTS are found in the southern third of NTS, outside the current areas of nuclear test activities in Yucca Flat, Rainer Mesa, and Pahute Mesa (DOE 1991).

There are many archaeological sites on the Pahute and Rainer Mesas testing areas and there are also some sites of historical interest on the NTS. The principle sites include the remains of primitive stone cabins with nearby corrals at three springs, a natural cave containing prospector's paraphernalia in Area 30, and crude remains of early mining and smelting activities.

In 1991, 17 preactivity surveys were conducted for archeological sites on the NTS, and reports on the findings were prepared. These preactivity surveys identified 56 sites containing previously unknown archeological information. These sites were added to the cultural resources inventory files and site records, and all artifacts collected from the NTS were processed for storage. Due to avoidance of all potentially significant sites by activities at the NTS, no test excavations, data recovery plans, or data-recovery projects were undertaken in 1991.

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Excluding Clark County, the major population center (approximately 741,000 in 1990) near the NTS, the population density within a 150-kilometer radius of the NTS is about 0.5 persons per square kilometer. In comparison, the 48 contiguous states (1990 census) had a population density of approximately 29 persons per square kilometer. The estimated average population density for Nevada in 1990 (including Clark County) was 2.8 persons per square kilometer. The off-site area within 80 kilometers of the NTS control point is predominantly rural. CP-1 (a building at the control point) historically has been the point from which distances from the NTS are determined (DOE 1991).

Several small communities are located in the area, the largest being in the Pahrump Valley. This growing rural community, with an estimated population of 15,000, is located 80 kilometers south of CP-1. The Amargosa Farm area, which has a population of about 950, is located about 50 kilometers southwest of CP-1. The largest town in the near off-site area is Beatty, which has a population of about 1500 and is located approximately 65 kilometers to the west of CP-1. The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The National Park Service (DOE 1991) estimated that the population within the monument boundaries ranges from a minimum of 200 permanent residents during the summer months to as many as 5000 tourists and campers on any particular day during "Death Valley Days" in the month of November. The largest nearby population in this desert is the Ridgecrest-China Lake area, about 118 mi southwest of the NTS, with a population of about 28,000. The next largest population is in the Barstow area, located 165 mi southwest of the NTS with a 1991 population of 21,000. The Owens Valley, where numerous small towns are located, lies 31 mi west of Death Valley. The largest town in the Owens Valley is Bishop, located 140 mi northwest of the NTS, with a population of 3500.

Recreational areas lie in all directions around the NTS and are used for such activities as hunting, fishing, and camping. In general, the camping and fishing sites to the northwest, north, and northeast of the NTS are used throughout the year except for the winter months. Camping and fishing locations to the southwest, south, and southwest are used throughout the entire year. The peak hunting season is from September through January.

I.I.2 Commercial Disposal Facility at Clive, Utah

The preferred alternative for waste material of Operable Unit 1 calls for the disposal of wastes at a commercial disposal facility in Clive, Utah. The facility is located on the eastern edge of the Great Salt Lake Desert, 3 mi west of the Ceder Mountains. Owned by the State of Utah, the 10 mi area around the site is rarely used due to its remoteness from urbanized areas. The area is uninhabitated by humans and only occasionally used for grazing and off-road vehicles. The only other land use within the 10 mi radius is for transportation. The Interstate 80 highway and the Union Pacific railway pass 2.5 mi and 1 mi north, respectively, of the site. Because the facility is located in an

area with an arid climate far away from any population centers, the lack of human habitation offers many advantages from a long-term risk standpoint.

The commercial disposal facility site has probably been used for grazing since the days of the early settlers. No events of historical significance are known to have occurred at the site. The Donner Trail probably passed north of the site, but the trail's exact location is unknown. A cultural resource inventory for the facility was performed in August 1981, by the Archaeological Environmental Research Corporation (DOE 1984). No cultural resource sites were found. The ground to air pilotless aircraft launch site and blockhouse is listed in the National Register of Historic Places and is approximately 10 mi west of the facility. The Gosepa Settlement Cemetery is located approximately 23 mi southeast of Clive.

The proposed disposal site is located in the basin and range physiographic province which covers nearly all of Nevada and parts of California, Oregon, Idaho, Arizona, New Mexico, and Texas. It is characterized by broad, flat basins occasionally interrupted by small mountain ranges. The area within a 10 mi radius is typical of this province. Because of the flatness of the terrain, vistas of 30 mi are common. The Visual Resource Inventory and Evaluation System (DOE 1984) was used to rate the scenic quality of the disposal facility relative to the physiographic province. This system employs a scale of 0 to 33, with higher ratings (19 or above) indicating that special management attention is required. The combination of landform, vegetation, water, color, influence scarcity, and cultural modification variables were used to derive a total score of 12 for the area surrounding the disposal facility. This low-to-medium rating for scenic quality indicates no special management attention is required for the site.

The commercial disposal facility is located within a relatively flat area along the eastern edge of the Great Salt Lake Desert, which extends approximately 60 mi from the Nevada border on the west to a series of north-south-trending mountain ranges on the east. The eastern edge of the desert in the vicinity of the site is formed by the Ceder Mountains, which rise to elevations of approximately 7700 ft, approximately 3500 ft above the desert floor. The proximity of this mountain range results in a generally westward slope to the site, with drainage into the Great Salt Lake Basin. The site has a topographic relief of less than 11 ft.

Because of the lack of detailed subsurface data concerning the bedrock, the exact depth to and relationships among various units at the disposal facility are unknown (DOE 1984). Lone Mountain, located 3 mi east of the site, has a core of Paleozoic rocks. These include, from west to east, the Grandeur Member of the Park City Formation, an unnamed Permian formation, and Unit 5 of the Oquirrh Formation. These well-indurated limestones and sandstones strike slightly east to north and dip steeply (72 to 74 degrees) to the west. Lone Mountain represents the west limb of a

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north-trending anticline, which is in turn located on the upper plate of the Lone Mountain Thrust Fault, a slightly northwest-trending Laramide (early Tertiary) low-angle fault.

The scattered, low hills about 1.5 mi west of the disposal facility site also contain outcrops of Paleozoic Oquirrh Formation (DOE 1984). These rocks may represent the northern extent of a slightly northeast-trending overturned anticline. The facility may be located in the syncline between this anticline and the Lone Mountain anticline to the east. The Grayback Hills 3.5 mi northwest of the disposal facility (just north of Interstate 80) are formed by remnants of Late Tertiary basalt and basaltic andesite flows (DOE 1984). These flows are the only apparent evidence near the site of Late Tertiary tectonism.

The commercial disposal facility site lies in a region which contains active faulting. Seismogenic sources include zones of faulting along the east flank of the Ceder Mountains, the east flank of the Newfoundland Mountains, the west flank of the Stansbury Mountains, and within Puddle Valley. The density of possible seismogenic sources is considerably less than along the Wasatch Front located about 65 mi east of the disposal facility. The site is located within the Great Basin in the basin-and-range Province (BAR) in western Utah, lying in a transition zone between exposed horsts and grabens (mountain ranges and valleys) to the east and buried horsts and grabens to the west. The surrounding area does not have recorded historical seismicity, but nearby seismogenic areas and geologic structures could pose a hazard to the site.

Surface and subsurface conditions at the disposal facility and vicinity were evaluated through the drilling, logging, and sampling of 13 exploration borings. The logs of the exploration borings are available in the Uranium Mills Tailings Radiation Control Act project office in Albuquerque, New Mexico. Surficial soil encountered in the 13 exploration borings generally consist of light brown to tan, sandy to clayey silt. This soil was classified as either stiff or very stiff and was noted to contain a small pinhole structure and bedding layers that range from approximately .06 to 12 ft (DOE 1993).

An interlayered lacustrian deposit, ranging from relatively clean fine-and medium-grained sands to silty clays, underlies the surficial material. This interlayered soil sequence appears to be random and no definite pattern or predominant material type could be correlated among individual borings. The soil is layered but varied in thickness and is generally classified as stiff to very stiff while the cohesionless materials are generally medium dense to dense. This interlayered sequence extends to depths between 45 and 51 ft.

No surface water bodies are present in the commercial disposal site area. The nearest stream channel ends about 2 mi east of the site and is typical of all the drainages along the transportation corridors within about 20 mi. The site lies to the west of the Ceder Mountains in a relatively flat basin. The streams within the area do not reach the site; the channels end 2 mi east of the site. This indicates that flows normally infiltrate or evaporate before reaching the site.

There are two major groundwater systems in the area: (1) the valley fill and (2) the alluvial fans bordering the desert. The recharge area for the alluvial fill occurs in the mountains bordering the desert. Direct infiltration of incident precipitation is not a significant component of the total groundwater regimen. Groundwater monitoring wells indicate groundwater lies 20 to 30 ft below ground surface. The principle direction of groundwater flow within the disposal site region is to the west. Locally, however, the direction of the groundwater flow is modified by both the surface topography and by the stratigraphy at depth. The direction of groundwater movement appears to be mainly to the northeast. The hydraulic gradient in this direction is small, approximately 3 ft per mile.

Regional temperatures range from 27°F in January to 79°F in July. Normal extremes range from nighttime lows of 19°F in January to daytime highs of 92°F in July. The average rainfall is only 5 in. per year. Thunderstorms occur in the summer and occasional snowfall occurs in the winter.

Soil at the disposal facility site is characterized as having a horizon of clay and alkali (sodium) accumulation. The soil lacks moisture for plant growth for long periods and is low in organic matter (DOE 1984). The dry subsurface soil is powdery and easily dispersed in the air by traffic of any kind. This highly saline, slowly permeable soil in this extremely arid location is unsuitable for reestablishing a lasting, self-sustaining vegetation to protect the soil covering the disposed materials. Even if the low precipitation could be overcome by irrigation, the nature of the soil would impose insurmountable problems that would prevent satisfactory plant cover within 10 to 20 years (DOE 1984). Soil with these characteristics will act as a barrier to all but the most shallowly rooted plant species, and density of the clay will deter burrowing by small animals.

The vegetation of the disposal facility site is a homogeneous, semidesert low shrubland, primarily composed of shadscale *(Atriplex confertifolia)*. The shrubland is part of the Northern Desert Shrub Biome of the Cold Desert Formation (DOE 1984). Plant communities identified on the site are

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Shadscale-Gray Molly *(Kochia americana var. vestita)*, a transitional community type of Shadscale-Gray Molly-Black Greasewood *(Sarcobatus vermiculatus)*, and Black Greasewood-Garder Saltbush *(Atriplex nuttallii)*. Vegetation patterns at the site are correlated with soil salinity and corresponding shifts in presence or abundance of species. All three communities are low in species diversity. Seep-weed or inkweed *(Suaeda torreyana)* and scattered perfoliate pepperweed *(Lepidium perfoliatum)* are the only prominent understory species of the Shadscale-Gray Molly community. This community occurs over most of the site, although black greasewood becomes prominent enough on the eastern quarter to form a Shadscale-Black Greaseweed-Gray Molly community (DOE 1984).

Animal species using the shadscale flats and greasewood as habitat typically include the black-tailed jackrabbit *(Lepus californicus)*, the deer mouse *(Peromyscus maniculatus)*, the horned lark *(Eremophila alpestris)*, and the desert horned lizard *(Phrynosoma platyrhinos)*; species diversity is low. All of these animal species could use the site for breeding or nesting. Aquatic ecosystems do not occur on the disposal site nor do any threatened or endangered species reside in the area.

The commercial mixed waste disposal facility is located in Toole County, Utah. The county encompasses 700 square miles within the state and had a population in 1990 of 26,000, representing approximately 1.5 percent of the population of Utah. (The population of Utah was 1,723,000 in 1990). The population in Toole County has increased on the average of 3.2 percent between 1970 and 1980; however, it remained constant over the past ten years at approximately 26,000.

Most lands within a 10 mi radius of the site are used very rarely because of their remoteness from urbanized areas and because of the poor spill, occasionally muddy conditions, and sparse vegetation that are characteristic of the region. Sheep grazing and recreational-vehicle driving are the primary uses of the area, but such uses are apparently light. Although no reports on land uses in the vicinity could be found, numerous trails in the area indicate that it has been used on occasion for recreational vehicle purposes, and much of the vicinity may be used on occasion for hunting. The only other land use within a 10 mi radius is for transportation, specifically Interstate 80 and the Union Pacific railway system.

APPENDIX J

FLOODPLAIN/WETLAND ASSESSMENT FOR THE OPERABLE UNIT 5 PREFERRED ALTERNATIVE

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LIST OF ACRONYMS

ARAR	applicable or relevant and appropriate requirement
AWWT	advanced wastewater treatment
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers
DOE	U.S. Department of Energy
FEMP	Fernald Environmental Management Project
FS	feasibility study
MSL	mean sea level
NTS	Nevada Test Site

J.1.0 INTRODUCTION

The Fernald Environmental Management Project (FEMP) is divided into five distinct operable units. This feasibility study (FS)concerns Operable Unit 5, which consists of environmental media -- groundwater, surface water, soil, sediment, flora, and fauna. The Operable Unit 5 FS evaluates the range of available remedial action alternatives addressing final disposition of Operable Unit 5 wastes. The primary objective of the Operable Unit 5 remedial action is to protect human health and the environment by implementing long-term cleanup solutions.

This appendix covers the floodplain/wetland assessment. Executive Order 11990 (Protection of Wetlands) and Executive Order 11988 (Protection of Floodplains), which are implemented by U.S. Department of Energy (DOE) Regulation 10, Code of Federal Regulations (CFR) 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements," specifies the requirement for a floodplain/wetland assessment in cases where the DOE is responsible for providing federally undertaken, financed, or assisted construction and improvements that may impact floodplains or wetlands. Pursuant to 10 CFR 1022.5 and 1022.11, the DOE has determined that a floodplain/wetland assessment is applicable for the representative alternative being considered for Operable Unit 5. A floodplain/wetland notice of involvement will be issued in the Federal Register to satisfy public notice requirements of 10 CFR 1022.14.

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J.2.0 PURPOSE AND NEED

Facilities and environmental media at the FEMP site contain radioactive and chemical constituents at levels which exceed certain federal and state standards for protecting human health and the environment.

The purpose of the Operable Unit 5 FS is to evaluate and select a remedial action alternative for Operable Unit 5 to preclude potential impacts to human receptors and the environment in the future. The alternatives evaluated in the FS would require activities that would impact wetlands and floodplains. Therefore, the DOE is preparing this floodplain/wetland assessment.

J.3.0 DESCRIPTION OF THE PROPOSED ACTION

The preferred alternative (Alternative 3A, Case 7) for Operable Unit 5 involves groundwater treatment, soil/sediment excavation, on-property disposal, and off-property disposal to the Nevada Test Site (NTS). Soil/sediment would be excavated and placed in an on-property engineered disposal cell or transported off site by truck to NTS, depending on contaminant concentrations. Soil/sediment that exceed remediation goals based on protection of the expanded trespasser, recreational user of an undeveloped park, the off-property farmer, and the Great Miami Aquifer will be contained within the on-property disposal cell. Soil and sediment that does not meet the on-property disposal cell waste acceptance criteria will be transported off property to NTS. All excavated areas will be backfilled with clean fill and revegetated.

Groundwater from the Great Miami Aquifer exceeding contaminant levels suitable for drinking water and perched groundwater zones exceeding remediation goals based on protection of the on-property resident farmer would be removed. Groundwater would be extracted, treated at the advanced wastewater treatment (AWWT) facility, and discharged to the Great Miami River. On-property storm water, remediation systems wastewater, and perched groundwater recovered from excavated soil would also be treated by the AWWT facility before discharge to the Great Miami River. Waste sludges generated by the water treatment processes would be dewatered at the AWWT dewatering system and transported off property for disposal. Spent treatment media (e.g., exhausted ion exchange resin and activated carbon) and concentrated contaminant residues would be cement stabilized and transported off property for disposal.

The disposal cell would be sited to take advantage of the most favorable geology. The disposal cell, along with the remainder of the FEMP property, would remain under federal ownership. At the discretion of the federal government, areas of FEMP property outside the disposal cell area would be released for alternate uses including industrial development or recreational use.

J.4.0 FLOODPLAIN/WETLAND EFFECTS

J.4.1 FLOODPLAINS

Floodplains within the FEMP site property are confined to the north-south corridor containing Paddys Run, which has also been designated as a water of the United States and the State of Ohio (Figure J.4-1). Outside the boundaries of the FEMP site, the 100- and 500-year floodplain of the Great Miami River extends west of the "big bend" area and northward along Paddys Run, from the confluence of the two streams past the southern boundary of the FEMP site (Figure J.4-2). The 100-year floodplain has been estimated to entail 1600 acres from river mile 19 to river mile 24 of the Great Miami River (DOE 1991).

J.4.1.1 Floodplains Within Operable Unit 5

A study by Parsons (1993) examined the 100- and 500-year floodplain along Paddys Run. The results of this study predicted a 100-year flood flow of approximately 315.8 cubic meters per second (11,150 cubic feet per second). Elevations range from 542 feet above mean sea level (MSL) at the southern boundary of the floodplain study area to 567 feet above MSL at the northern tip (Figure J.4-1). Within Operable Unit 5, the 100- and 500-year floodplain are contiguous due to the relatively steep slopes along the banks of Paddys Run.

J.4.1.2 Floodplain Impacts

The preferred alternative of Operable Unit 5 would result in excavation and grading activities in the 100- and 500-year floodplain of Paddys Run. Direct impacts to the floodplain would occur in the short term during the operation of heavy construction equipment resulting in the excavation of contaminated soil within the floodplain. Upon completion of excavation, the excavated areas would be backfilled with clean soil and regraded to near original contours.

Indirect impacts to the floodplain could occur from remedial activities, resulting in sediment deposition into the floodplain. Measures to minimize or eliminate these adverse impacts may include the utilization of silt fences, straw bales, and dust suppressants. Remedial activities could result in short-term impacts to the floodplain of Paddys Run. However, positive long-term impacts would occur as a result of contaminant removal and containment.

J.4.2 WETLANDS WITHIN OPERABLE UNIT 5

A jurisdictional wetland delineation has been approved by the U.S. Army Corps of Engineers' (COE) Louisville District, which establishes jurisdictional wetland boundaries and waters of the United States at the FEMP (EBASCO Environmental 1993). The delineation was prepared using the routine determination, on-site inspection method, in accordance with the 1987 Corps of Engineers Wetland

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Delineation Manual, which revealed a total of 36 acres of freshwater wetlands. These wetlands are comprised of the following types within Operable Unit 5: 27 acres of palustrine forested wetlands, 7 acres of drainage ditches/swales, and 2 acres of isolated persistent emergent and scrub/shrub wetlands (Figure J.4-3). Wetlands were delineated using routine on-site methods.

J.4.2.1 Wetland Impacts

Implementation of the preferred alternative (Alternative 3A, Case 7) would result in the loss of 7 acres of drainage ditch/swales and 2 acres of isolated persistent emergent and scrub/shrub wetlands. The total wetland area that would be impacted measures 9 acres.

Direct impacts would occur from continuous equipment traffic, soil removal, and construction activities resulting in physical disturbance and filling of wetland areas. Indirect impacts would include the migration of eroded soil, sediment deposition, and dispersion of fugitive dust to the wetland areas. Engineering controls would be implemented during all remedial activities to minimize indirect impacts. Controls would include use of silt fences, straw bales, and dust suppressants. Mitigation for wetland impacts will be determined using the 404 (b) (1) guidelines of the Clean Water Act, in consultation with the COE, U.S. Environmental Protection Agency, and Ohio Environmental Protection Agency.

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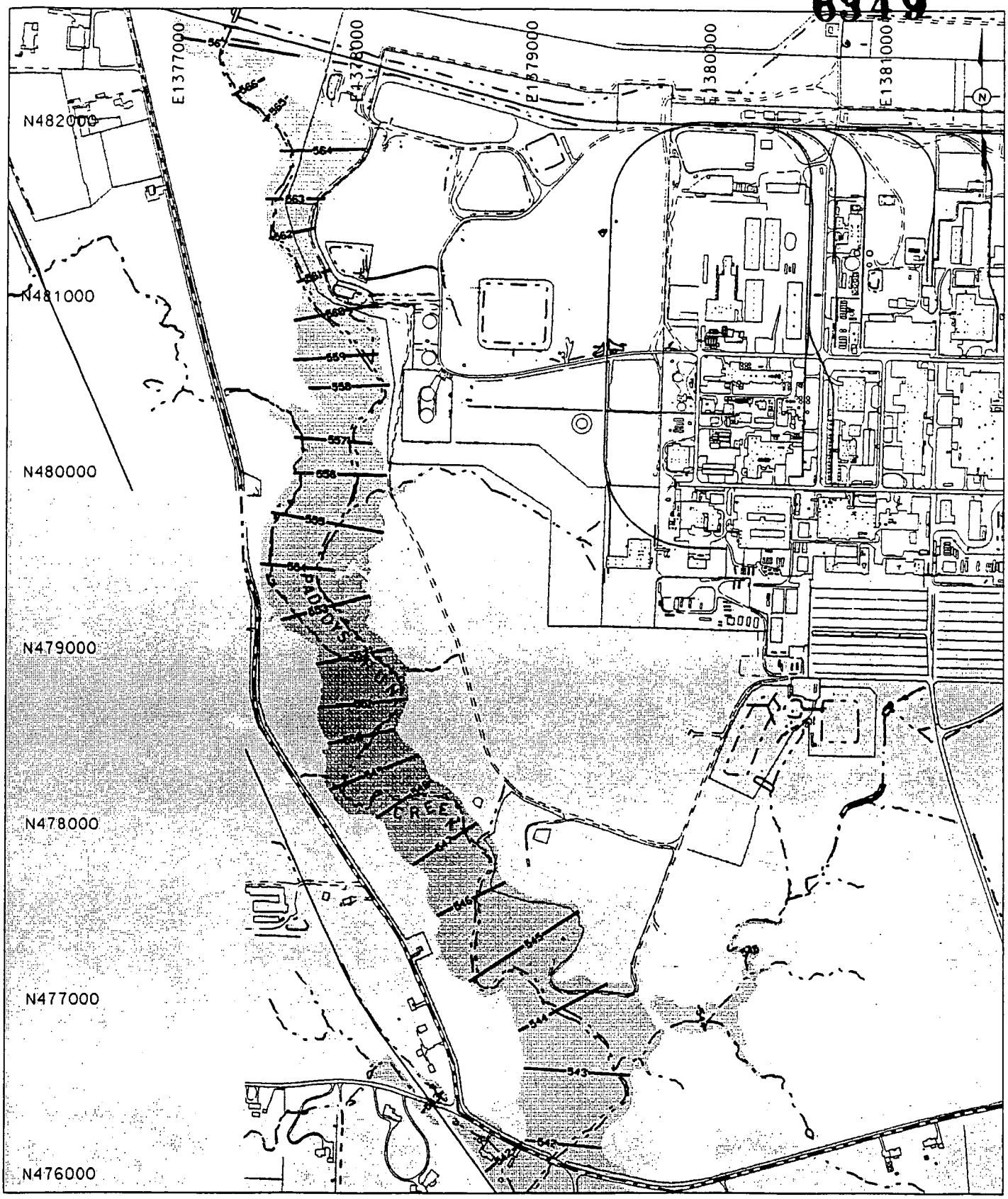

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FIGURE J.4-1 PADDYS RUN CREEK 100 AND 500 YEAR FLOODPLAIN

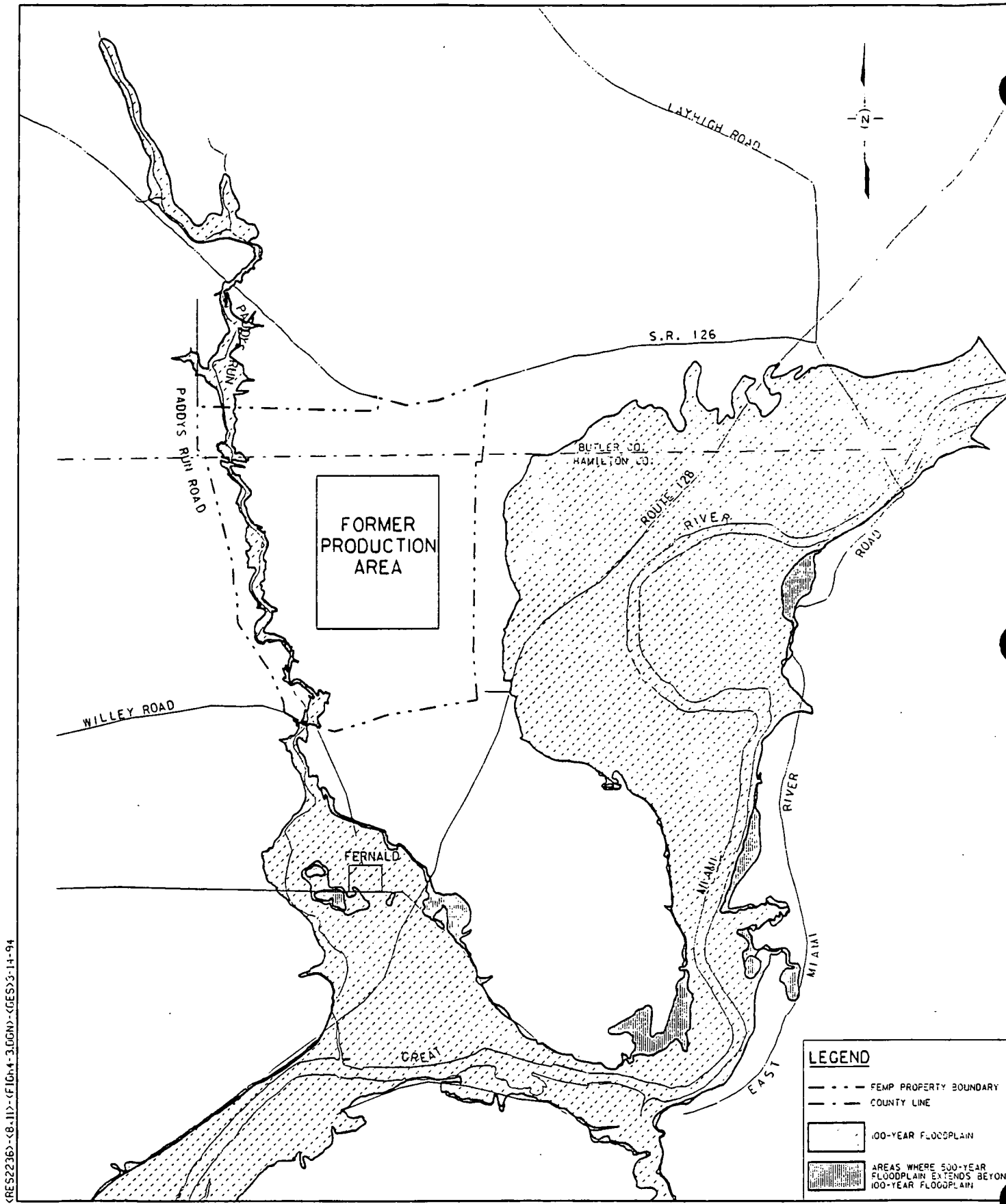

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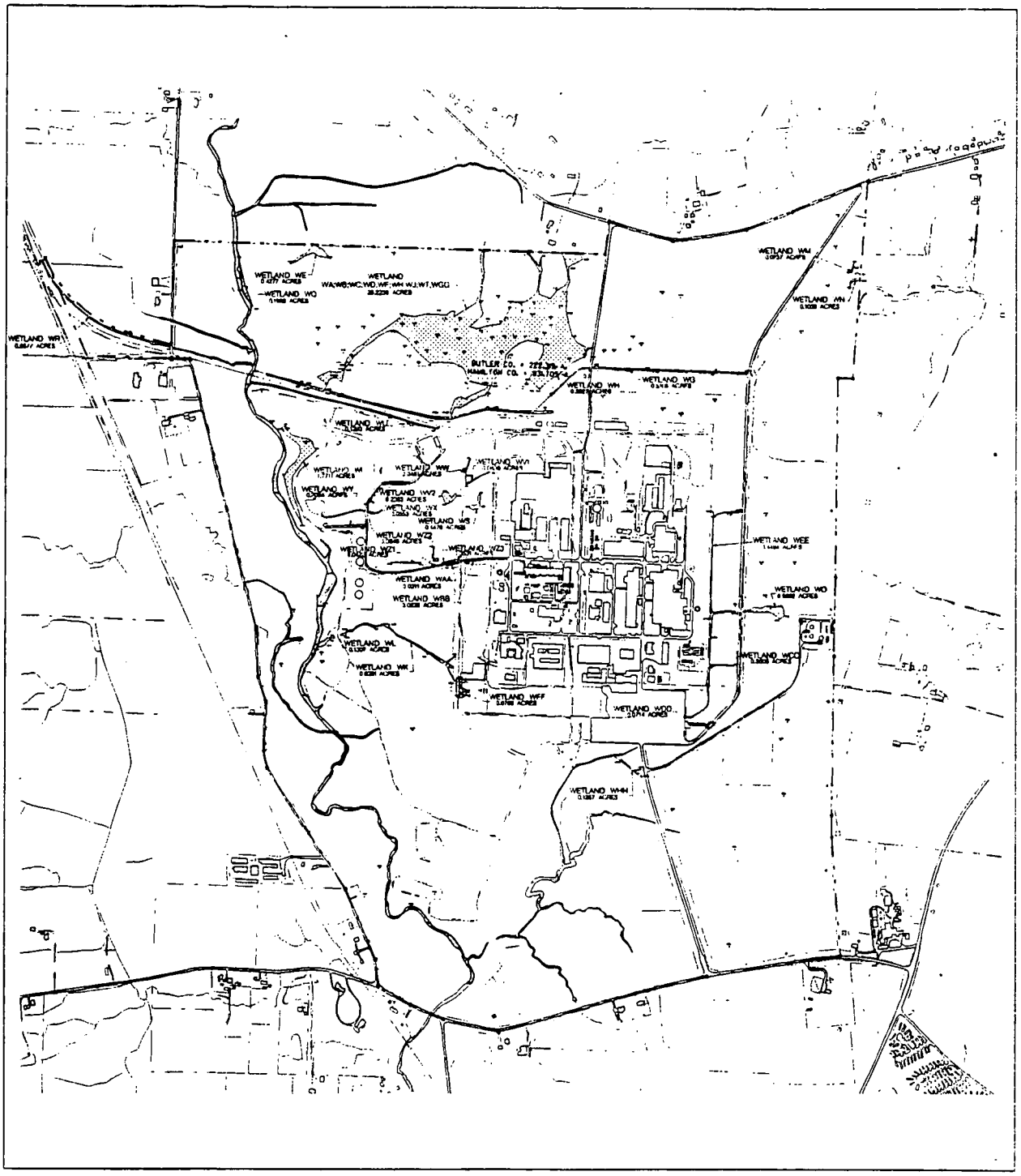
FIGURE J.4-2 GREAT MIAMI RIVER AND PADDYS RUN
100-YEAR AND 500-YEAR FLOODPLAIN



LEGEND

- WETLAND AREA
- WATERS OF THE U.S.
- SITE BOUNDRY
- COUNTY LINE
- PHOTO LOCATION
- DREDGED OR FILLED, NO LONGER MEETS WETLAND CRITERIA

SCALE

0 1550 3100 FEET

SCALE

0 225 950 METERS

RES2236 8x11 fig1-1.dgn cru2 GES 3-16-94

FIGURE J.4-3 1993 JURISDICTIONAL WETLANDS & WATERS OF THE U.S. FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

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J.5.0 ALTERNATIVES CONSIDERED

The activities discussed in the previous sections were selected from seven possible alternatives. The major alternatives were no action, on-property disposal (including a disposal cell or consolidated area), and off-property disposal. Groundwater treatment is the same for all alternatives, as previously discussed in Section J.3.0.

J.5.1 NO-ACTION ALTERNATIVE

Under this alternative, all environmental media would remain in place. The no-action alternative would not impact wetlands in the short term; however, no further action could result in impacts to all wetlands within the FEMP boundaries from the migration of Operable Unit 5 contaminants. Floodplains would remain in place but potentially would become increasingly contaminated as a result of contaminant migration. Furthermore, the no-action alternative is not protective of human health and the environment, does not comply with applicable or relevant and appropriate requirements (ARARs), and does not provide long-term effectiveness and permanence. Therefore, the no-action Alternative was not selected.

J.5.2 ON-PROPERTY DISPOSAL

Alternatives 2A (Cases 1 and 2), 2C (Case 2), 3A and 3C (Cases 3-7), and 4A and 4C (Cases 8 and 9) involve excavation and on-property disposal (disposal cell or consolidation) of soil.

Alternatives 2A (Case 2), 2C (Case 2), and 3A and 3C (Case 3) would result in the loss of 6.5 acres of palustrine forested wetlands, 7 acres of drainage ditch/swales, 2 acres of isolated persistent emergent and scrub/shrub wetlands, and 1.5 acres of miscellaneous wetland types from construction equipment movement. The total wetland area that would be impacted measures 17 acres. Short-term impacts would occur to the 100- and 500-year floodplain of Paddys Run as a result of soil removal. Upon completion of excavation, the excavated areas would be backfilled with clean soil and regraded to near original contours. Therefore, remedial activities would not alter flow patterns or uses of the floodplain.

Alternatives 3A and 3C (Cases 4 through 7) and 4A and 4C (Cases 8 and 9) would result in the loss of 7 acres of drainage ditch/swales and 2 acres of isolated persistent emergent and scrub/shrub wetlands. Total wetland areas to be impacted are 9 acres. Short-term impacts would occur to the 100- and 500-year floodplain of Paddys Run as a result of soil removal. Upon completion of excavation, the excavated areas would be backfilled with clean soil and regraded to near original contours. Therefore, remedial activities would not alter flow patterns or uses of the floodplain.

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Alternative 2A (Case 1) would result in the loss of 27 acres of palustrine forested wetlands, 7 acres of drainage ditch/swales, and 2 acres of isolated persistent emergent and scrub/shrub wetlands. The total impacted wetland area measures 36 acres. Short-term impacts would occur to the 100- and 500- year floodplain of Paddy Run and the Great Miami River as a result of soil removal.

Wetland impacts for all on-property disposal alternatives would be long term and direct from continuous equipment traffic and soil removal, resulting in physical disturbance and filling of wetland areas.

J.5.3 OFF-PROPERTY DISPOSAL

Alternatives 1 (Cases 1 and 2) and 2C (Case 1) involve off-site disposal of waste to an off-property commercial disposal facility. Impacts to wetlands from Alternatives 1 and 2C (Case 1) are the same as Alternative 2A (Case 1). Impacts to wetlands from Alternative 1 (Case 2) are the same as Alternative 2A (Case 2).

Wetland impacts would be long term and direct from continuous equipment traffic and soil removal, resulting in physical disturbance and filling of wetland areas.

Impacts to the floodplain of Paddys Run for these alternatives would be similar to the on-property disposal alternatives. In addition, these alternatives would also impact the floodplain of the Great Miami River.

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APPENDIX K

COST ESTIMATE

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K.1.0 OVERALL ESTIMATE BASIS

The cost estimate basis provides the backup data, assumptions, and information used to prepare the cost estimates for the Operable Unit 5 remedial alternatives. The cost estimates are based on the detailed descriptions of the components as contained in Appendix A and general information about Fernald Environmental Management Project (FEMP) activities. Pricing is from vendor quotes, Means, Richardsons, USACOE, and Factory Quote, tempered by estimator experience. The labor rates applied against manhours in the estimate are the FEMP Craft Wage rates effective March 1, 1994.

Component and alternative cost estimates do not include site overhead costs - the cost for typical daily operations (e.g., labor, utilities, supplies) not specifically for remedial activities.

K.1.1 METHODOLOGY

Fourteen remedial alternatives were retained for detailed analysis as described in Section 4.0. As part of the detailed analysis, the cost of each remedial alternative will be evaluated. To develop remedial alternative cost estimates, the methodology described in the following sections was developed. Figure K.1-1 provides a graphical representation of the methodology.

K.1.1.1 Identify Common Remedial Components

A review of the retained remedial alternatives reveals that there are a number of remedial components which are common to two or more remedial alternatives. These remedial components comprise the building blocks of the remedial alternatives.

The following common remedial components were identified:

- Soil Excavation
- Soil Washing
- Off-Site Disposal
- Stabilization
- Consolidation
- On-Property Disposal
- Backfill
- Long-Term Environmental Monitoring
- Great Miami Aquifer Groundwater Extraction
- Groundwater and Wastewater Treatment
- Central Storage Facility

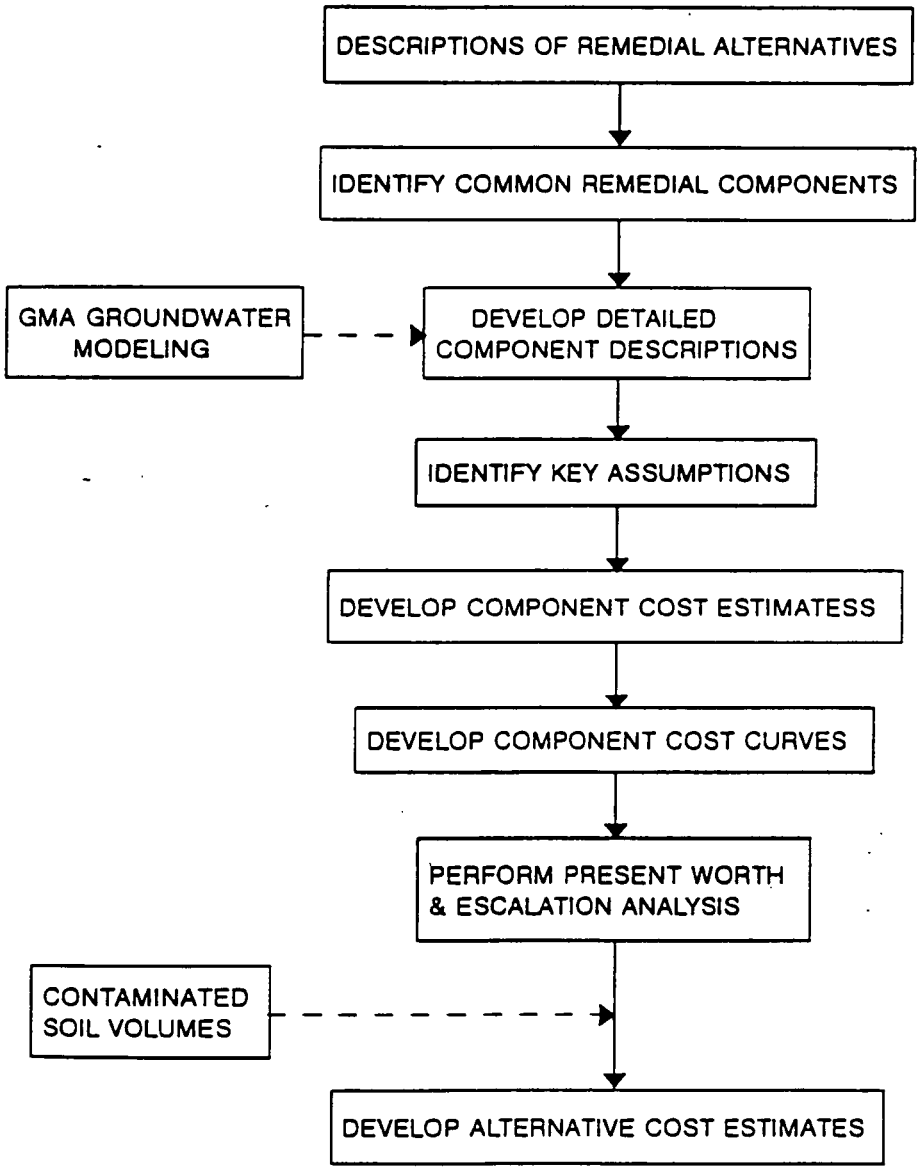

FIGURE K.1-1 - COST ESTIMATING METHODOLOGY

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K.1.1.2 Develop Detailed Component Descriptions

Appendix L contains a detailed description of each remedial component. These detailed descriptions were developed based upon the strategies for remediating various contaminated media as described in Section 2.0, results of the Great Miami Aquifer Groundwater Modeling (Appendix F), general information about FEMP activities, and general industry and engineering practices. The detailed component descriptions provide the engineering basis for developing the component cost estimates.

K.1.1.3 Identify Key Assumptions

Key assumptions were made to establish a consistent approach to developing the component cost estimates. They are listed below:

- Soil/sediment remediation will start in the year 1998. Operating periods for soil-related remedial components are as follows:
  - Soil/sediment excavation and backfill will occur for 22 years via eleven consecutive 2-year construction contracts.
  - Soil treatment (soil washing or stabilization) will occur for 22 years. Soil washing and stabilization have been screened out as primary remediation technologies but have been retained as possible support technologies. Costs are included for comparative purposes.
  - Off-site disposal will occur for 22 years
  - Consolidation will occur for 22 years via eleven consecutive 2-year construction contracts.
  - On-property disposal cell construction will occur for 22 years via eleven consecutive 2-year construction contracts.

- Groundwater remediation will start in the year 2000 following a 5-year construction period (1995-1999). Operating periods for groundwater-related remedial components are as follows:
  - Great Miami Aquifer groundwater extraction and treatment will occur for 30 and 75 years (including the 5-year construction period) for the MCL and 10^{-6} clean-up goals, respectively.

- The existing site environmental monitoring program will continue unchanged until 1998. Additional environmental monitoring, including groundwater, air, and surface water monitoring, will occur in three phases starting in 1998 as follows:
  - The construction monitoring period will last for 22 years, the duration of soil remediation activities
  - The post-construction continued groundwater remediation period will last approximately 5 or 50 years following closure of the on-property disposal facility for the MCL and 10^{-6} clean-up goals, respectively.
  - The post-closure long-term monitoring period will last for an assumed period of 50 years.

- All Engineering Design costs (i.e., Title I, II, and III) are shown in the first year on the life-cycle estimate sheets. In actuality, Title III costs may continue into the

first or second year of operations. For simplicity, it is assumed that all engineering costs are 10 percent of the construction direct and indirect costs.

- All construction (e.g., erection of facilities, installation of equipment, etc.) is assumed to be performed by a general contractor or subcontractor. Construction for all soil-related components will start and finish in 1997. All construction costs are therefore subject to the appropriate contractor markups.

- All large process and material handling equipment required for soil remediation activities will be purchased by the construction contractor, and are included in the direct construction equipment costs. The acquisition of large scale process equipment required for treatment technologies (i.e., soil washing and stabilization) will be procured by the site operating contractor and installed by the construction contractor. All such equipment and the purchase of material handling containers if required will be purchased prior to the initial start of operations. These costs are considered acquisition costs, not operating costs.

- Remedial operations and maintenance will be performed by the site operating contractor. Workers will be employed by the operating contractor and work will take place on a yearly basis for processing and material handling type activities. However, annual operations and maintenance activities for soil excavation, backfill, on-site disposal cell construction, and consolidation area construction will be performed by a construction contractor.

- For simplicity, annual costs are distributed uniformly throughout the life cycle duration.

- Boundaries are established for each component to distinguish when construction ends and operations begin. Cost breakdowns are based on these boundaries. Reference the key assumptions for individual components in Section K.3.0 for further detail.

- A base cost estimate was prepared for soil treatment components (Soil Washing and Stabilization) based on a 20 tons/hour treatment rate. Since the soil remediation period is fixed at 22 years, equipment sizes and treatment capacities will change depending on the total volume of soil treated. To address the changes in equipment capacities and the impacts to construction costs, a six-tenths factor rule is applied to provide a multiplying factor for the variations in volume. The factor is applied to the component construction costs only. Changes in equipment requirements during the operations and maintenance phase are increased or decreased proportionately.

K.1.1.4 Develop Component Cost Estimates

Cost estimates were developed for each remedial component based on the detailed descriptions of each component and the key assumptions identified. All component costs are estimated in 1994 constant dollars. The Component Cost Summary include construction costs, operations and maintenance costs, post remediation costs, risk budget and contingency, and the total project cost. Life cycle construction, operation and maintenance, and post-remediation costs, less risk budget and contingency, are provided as

constant-dollar cash flows for the planning horizon for the component. Each of these costs is discussed in greater detail below.

Construction Costs

Construction costs include expenditures for the equipment, labor, materials, and indirect costs necessary to install remedial actions.

Construction costs include engineering design cost plus direct and indirect field labor and materials to construct the facility. Indirect labor includes contractor supervision (field office overhead), equipment rental, temporary facilities, health physics, CERCLA training, payroll burden and benefits and overhead and profit. Other associated costs such as site contractor's purchased equipments and material, waste characterization, transportation, direct burial of materials, sales tax on materials, project management and construction management, are also included.

Operations and Maintenance Costs

Operations and maintenance costs are post-construction costs necessary to remove, treat, and/or dispose of contaminated media.

Operations costs include the cost of labor and staff required to operate the remediation facilities, utility costs such as electrical power and sewer, fuel costs, material handling costs, disposal costs, supplies, and sampling and analysis.

Maintenance cost includes repair or replacement of equipment and structures, maintenance personnel, and spare parts.

Post Remediation Costs

Post-remediation costs include decommissioning of remedial facilities and equipment after remediation goals have been met, and the associated long-term monitoring and maintenance of on-property disposal facilities.

Risk Budget and Contingency

A budget risk analysis was performed for each component using a computer program based on Monte Carlo simulation. The program input was developed as follows:

1. Within each remedial component, major cost elements related to construction, operations and maintenance, and post-remediation were identified.

2. Each cost element was then weighed against cost driver factors, such as Labor Efficiency, Material Pricing, Class (and extent) of Contamination, New Technology, New Laws and Regulations, Quantity Variation, and Project Definition. Low and high percentage ranges were assigned to each cost driver factor. The low and high cumulative totals were then used as input to the computer simulation.

The computer simulation output showed:

1. The Risk Budget and Overrun Analysis Output reflecting the chances of overrun percentage versus the percentage of risk budget of base estimate.

2. The frequency histogram of Project Cost Distribution for 2000 samples.

3. The Cumulative Overrun Curve representing the probability of cost overrun versus project cost.

Risk budget and overrun analysis were developed separately for each component. The risk budget percentage was based on a 50 percent chance of overrun. The contingency was then derived from the difference between the 5 percent and 50 percent chance of overrun of the base estimate.

The risk budget and contingency percentages were then applied to the sum of component construction, operations and maintenance, and post-remediation costs.

Total Project Cost

The total project cost is the sum of the construction, operations and maintenance, and post-remediation costs for each component and includes risk budget and contingency.

K.1.1.5 Develop Component Cost Curves

A cost curve is provided for each soil-related component. Cost curves are not provided for groundwater-related components since the Great Miami Aquifer groundwater extraction and treatment rate are based on computer modeling results. In addition, cost curves for soil washing and stabilization are not provided since these components have been screened out as primary remediation technologies. The curve represents a relative correlation between cost and a given soil volume. Supplemental cost estimates were prepared to develop the appropriate number of points for the component cost curves. Component construction and operational strategies were developed for costing purposes. Different volume scenarios were selected and costed for addressing contaminated soils of 1,500,000 yd^3, and 2,000,000 yd^3. The curve is then fitted to the points to present a smooth curve. Two curves are plotted for each component. The lower curve represents the raw cost versus volume. Raw cost includes construction, operations and maintenance, and post-remediation costs as previously described. The upper curve represents raw cost plus risk budget and contingency versus volume. The shaded area between each curve represents the cost range versus volume.

Environmental monitoring is required during construction of remediation facilities. In addition, long-term environmental monitoring is required for remedial components which include leaving contaminated media on site (e.g., Consolidation, On-Property Disposal Cell). These environmental monitoring costs are included with the applicable remedial components. However, the cost of site-wide environmental monitoring during remediation is included at the alternative cost estimate level.

Soil excavation includes contamination surveys. Contamination surveys are required to determine the extent of soil contamination, guide soil excavation, and certify excavated areas meet clean-up goals. Contamination survey costs are based on the areal extent of contamination and can't be tied to a contamination volume. Therefore, the cost of contamination surveys is included at the alternative cost estimate level.

K.1.1.6 Perform Present Worth and Escalation Analysis

Component cost estimates were developed in constant 1994 dollars. The anticipated annual costs over the study period for each component are summarized and represented in the "Life-Cycle Cost Analysis" estimate sheets for each component. To evaluate the FS alternatives, Present Worth Analysis is conducted on the annual expenditures of each component. The Present Worth Analysis utilizes the "Real Discount" rates established by the Office of Management and Budget, which include the adjustments for varying interest rates on annual constant-dollar cash flows. "Net Present Worth" costs are presented at the Alternative Cost Summary level adjacent to the total costs for the remedial components for each alternative. A Discount Rate of 2.8 percent has been used for the component Present Worth Analysis for specific planning periods.

In addition to the Present Worth Analysis, the total annual constant-dollar expenditures for each component have been escalated to present the affects of inflation (real dollars) in the year the costs are actually incurred. An average escalation rate of 3.7 percent was used in the analysis. The rate is based on the August 1994 Economic Escalation Indices for DOE construction projects established by the Office of Infrastructure Acquisition.

K.1.1.7 Contaminated Soil Volumes

Contaminated soil volumes were calculated for each case of each remedial alternative as described in Section 2.0. Table K.1-1 provides the total soil volumes associated with each remedial component of each remedial alternative and case. The volumes in Table K.1-1 also include 175,000 yd^3 of gravel which would be excavated from the former production area.

TABLE K.1-1

TOTAL SOIL VOLUMES

ALT. NO.	REMEDIAL COMPONENT	ALL VOLUMES IN CUBIC YARDS								
		CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9
1	EXCAVATE	9.65E+06	2.74E+06							
	OFF-SITE DISPOSAL	9.35E+06	2.40E+06							
	BACKFILL	2.90E+06	1.37E+06							
2A	EXCAVATE	9.65E+06	2.74E+06							
	DISPOSAL CELL	9.30E+06	2.37E+06							
	OFF-SITE DISPOSAL	5.00E+04	2.50E+04							
	BACKFILL	2.90E+06	1.37E+06							
2C	EXCAVATE	9.65E+06	2.74E+06							
	CONSOLIDATE W/ COVER	0.00E+00	1.24E+06							
	OFF-SITE DISPOSAL	9.35E+06	1.16E+06							
	BACKFILL	2.90E+06	1.37E+06							
3A	EXCAVATE			2.39E+06	2.20E+06	2.19E+06	1.79E+06	1.80E+06		
	DISPOSAL CELL			2.34E+06	1.75E+06	1.75E+06	1.75E+06	1.75E+06		
	OFF-SITE DISPOSAL			2.50E+04	2.50E+04	2.50E+04	2.50E+04	2.50E+04		
	BACKFILL			9.55E+05	8.29E+05	8.35E+05	8.35E+05	8.16E+05		
3C	EXCAVATE			2.39E+06	2.20E+06	2.19E+06	1.79E+06	1.80E+06		
	CONSOLIDATE W/ COVER			1.22E+06	6.52E+05	6.52E+05	6.52E+05	6.52E+05		
	OFF-SITE DISPOSAL			1.15E+06	1.13E+06	1.12E+06	1.12E+06	1.12E+06		
	BACKFILL			9.55E+05	8.29E+05	8.35E+05	8.35E+05	8.16E+05		
4A	EXCAVATE								2.19E+06	1.79E+06
	DISPOSAL CELL								1.75E+06	1.75E+06
	OFF-SITE DISPOSAL								2.50E+04	2.50E+04
	BACKFILL								8.39E+05	8.39E+05
4C	EXCAVATE								2.19E+06	1.79E+06
	CONSOLIDATE W/ COVER								6.52E+05	6.52E+05
	OFF-SITE DISPOSAL								1.12E+06	1.12E+06
	BACKFILL								8.39E+05	8.39E+05

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K.1.1.7 Prepare Alternative Cost Estimates

The cost of each remedial alternative is composed of the costs of its remedial components. Similar to the remedial component costs, remedial alternative costs consist of construction costs, operations and maintenance costs, post-remediation costs, and risk budget and contingency.

Using the component cost curves and calculated contaminated soil volumes described previously, a cost is determined for each component of each alternative. For example, Alternative 2A, Case 2, consists of the following remedial components:

- Soil Excavation
- On-Property Disposal Cell
- Off-Site Disposal
- Backfill
- Great Miami Aquifer Groundwater Extraction
- Groundwater and Wastewater Treatment
- Central Storage Facility
- Environmental Monitoring

Table K.1-1 provides the following contaminated soil volumes for Alternative 2A, Case 2:

- Soil Excavation = 2,740,000 yd^3
- Disposal Cell = 2,370,000 yd^3
- Off-Site Disposal = 1,160,000 yd^3
- Backfill = 1,370,000 yd^3

Using the cost curves developed for each remedial component, Alternative 2A, Case 2, costs for excavation, disposal cell, off-site disposal, and backfill were determined. The component costs for construction, operations and maintenance, post-remediation, risk budget and contingency, present worth, and escalated costs were determined for Alternative 2A, Case 2, using mathematical interpolation.

Great Miami Aquifer Groundwater Extraction and Groundwater and Wastewater Treatment costs for Alternative 2A, Case 2, were determined based on an MCL clean-up goal (6,300 gpm groundwater pumping and treatment rate) as described in Section L.0.

The Central Storage Facility cost is included for Alternative 2A, Case 2, for storing and packaging contaminated soils and treatment residues for off-site shipment and disposal.

Site-wide environmental monitoring costs incurred during the active remediation period (not associated with construction of remedial facilities) are included in the alternative cost estimate. Long-term environmental

monitoring associated with on-property disposal units are included in the respective remedial component cost estimates.

The cost of contamination surveys to determine the areal extent of contamination, guide soil excavation activities, and certify the achievement of clean-up goals are dependent upon the area and depth of excavation - not the volume of contaminated media. Therefore, contamination survey costs are included in the alternative cost estimate.

K.2.0 COST ESTIMATE FORMAT

The following sections describe the component and alternative cost estimate summary formats.

K.2.1 COMPONENT COST SUMMARY

Table K.2-1 provides an example of a Component Cost Summary (in this case for Groundwater Treatment). The following sections provide a line-by-line description of the Component Cost Summary. For the component cost estimates, it is assumed there is no distinction between the general construction contractor and construction subcontractors.

K.2.1.1 Construction Direct Costs

Construction Direct Costs include the cost of labor and materials required to construct facilities and install equipment for each component prior to the start of remedial operations. Construction Costs also include the cost to purchase and install major equipment within and around (roadways, etc.) facilities. Some facility utility systems (i.e., fire protection, electrical, lighting, fire alarms, etc.) were priced by the square foot based on historical cost data.

Construction radiological considerations and other non-productive items (not identified at the indirect Component Summary level) that may impact labor productivity are considered in the construction direct costs. Where applicable, a radiological adjustment factor of 1.30 was applied to the labor hours for that item to account for lost time due to the handling of hazardous materials. For the most part, site clearing and grubbing, erection of facilities, etc., will occur in clean areas, requiring little or no radiological adjustments to construction. Normal non-productive considerations (e.g. instruction, clean-up, etc.) were also applied to the appropriate construction estimate.

K.2.1.2 Construction Indirect Costs

The following sections describe general contractor and subcontractor indirect cost categories for each component estimate. The indirect costs are applied only at the component estimate level.

Contractor Supervision (Field Office Overhead)

This category includes the labor costs for general contractor and subcontractor administrative support staff. Examples include general superintendent, administrator, field office and material manager, construction accounting clerk, timekeeper, materials manager, cost engineer, construction inspector, etc. This markup is applied at 17 percent Construction Direct labor dollars.

TABLE K.2-1

COMPONENT COST SUMMARY EXAMPLE

COMPONENT COST SUMMARY

COMPONENT TITLE: GROUNDWATER & WASTEWATER TREATMENT
LOCATION: FEMP
VOLUME: 6300 GPM

SHEET: 1
DATE: 02-Nov-94
ESTD. BY J. ADAMS
CHKD. BY B.NEMADE
EST. FILE COMP13GT
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	EST. FILE COST	TOTAL COST
	GROUNDWATER TREATMENT		151,034	3,043,000	5,489,200	8,532,200
	AWWT SLURRY DEWATERING SYSTEM		36,972	741,400	689,900	1,431,300
CONSTRUCTION DIRECT COSTS			188,006	3,784,400	6,179,100	9,963,500
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				643,348		643,348
SMALL TOOLS/CONSUMABLES					227,064	227,064
CONTRACTOR EQUIPMENT RENTAL					626,100	626,100
TEMPORARY FACILITIES				79,472	147,592	227,064
TEMPORARY FACILITIES (HOOK-UP)				39,736	73,796	113,532
JOB CLEAN-UP				79,472	147,592	227,064
CONTRACTOR SAFETY				39,736	73,796	113,532
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				224,000		224,000
CERCLA (SITE ACCESS TRAINING)				128,100	134,550	262,650
PAYROLL BURDENS & BENEFITS				2,609,498		2,609,498
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				686,499	684,863	1,371,362
BOND				83,143	82,945	166,087
CONSTRUCTION INDIRECT COSTS				4,613,004	2,198,296	6,811,301
CONSTRUCTION DIRECT & INDIRECT COSTS				8,397,400	8,377,400	16,774,800
SAMPLING/ WASTE CHARACTERIZATION					1,420,700	1,420,700
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					9,506,900	9,506,900
PROJECT MANAGEMENT		8.00%				2,216,200
CONSTRUCTION MANAGEMENT		4.00%				671,000
FIELD SUPPORT						13,814,800
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				1,677,480
ENGINEERING COSTS						1,677,480
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					1,026,983
SUB-TOTAL CONSTRUCTION COSTS						33,294,063
SUB-TOTAL REMEDIATION O&M COSTS						225,805,898
SUB-TOTAL POST-REMEDIATION O&M COSTS						18,147,500
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)						277,247,461
RISK BUDGET		19.1%				52,954,265
CONTINGENCY		22.6%				62,657,926
TOTAL PROJECT COST						392,859,700

Small Tools and Consumables

This category includes material costs of tools and construction consumables, such as shovels, concrete buckets, welding equipment, pumps, hose, weld rod, etc. This markup is applied at 6 percent of Construction Direct labor dollars.

Contractor Equipment Rental

This category includes material costs of construction equipment used on the project, such as pickup trucks, forklifts, backhoes, dozers, heavy cranes, manlifts, etc. Construction equipment is not subject to sales tax since the sales tax is normally applied in the contractor lease agreement. It is assumed that all construction equipment will be furnished by the general contractor and the subcontractors.

Temporary Facilities

This category includes the labor and material costs for temporary buildings and structures, such as office trailers, tool sheds, break or change trailers, etc. This markup is applied at 6 percent of Construction Direct labor dollars and is distributed at 35 percent to labor and 65 percent to material costs.

Temporary Facilities (Hook-Up)

This category includes the labor and material costs for utility (i.e., electrical power, domestic water, sanitary sewer, etc.) hook-ups to office trailers and other temporary structures. This markup is applied at 6 percent of Construction Direct labor dollars and is distributed at 35 percent to labor and 65 percent to material costs.

Job Clean-Up

This category includes the labor and material costs associated with the daily cleaning of the work area to maintain a safe and clean work area. This category is not intended to address the wash-down of contaminated areas. This markup is applied at 6 percent of Construction Direct labor dollars and is distributed at 35 percent to labor and 65 percent to material costs.

Contractor Safety

This category includes general and subcontractor labor and material costs to conduct safety inspection-related meetings and purchase supplies. This markup is applied at 6 percent of Construction Direct labor dollars and is distributed at 35 percent to labor and 65 percent to material costs.

Health Physics

This category includes the labor costs of worker time for periodic radiological monitoring surveys and worker physicals. Labor costs will vary depending on the site conditions and job size. Health Physics typically includes the cost to purchase worker protective clothing. However, it is assumed that most new

facility construction activities will be performed in a clean area, requiring little or no personal protective clothing.

CERCLA (Site Access Training)

This category includes the labor and material costs of contractor personnel CERCLA training and testing requirements. All construction craftsmen are required to have safety training prior to working on site. They must undergo medical examinations (entry and exit) and bioassay testing as well as annual refresher training for the duration of the construction project. It is assumed that 20 percent of the work force will be affected by attrition, and additional CERCLA costs will therefore be incurred against the project.

Payroll Burdens and Benefits

This category includes the labor payroll and benefit costs the general contractor and subcontractors will incur in addition to the base salary for each construction craftsman. This markup is applied at 52 percent of Construction Direct labor dollars plus all previously listed Construction Indirect labor dollars.

Overhead and Profit

This category includes general contractor and subcontractor home office labor and material costs and profit. This markup is applied at 9 percent of all previous Construction Direct and Construction Indirect labor and material costs.

Bond

This category includes the labor and material costs for the general contractor and subcontractor to bond the projects. A markup of 1 percent is applied against the total of all previous Construction Direct and Construction Indirect labor and material costs.

K.2.1.3 Construction Direct and Indirect Costs

This line item sums the Construction Direct and Construction Indirect labor, material, and total costs.

K.2.1.4 Field Support Costs

The following categories address the site operating contractor's field support material costs for each component cost summary. These costs are applied only at the component estimate level. Not all of the following field support costs are included with each component cost estimate.

Sampling/Waste Characterization

This category includes the material cost to conduct a survey to verify the boundaries of excavation, determine whether sufficient quantities of contaminated soil have been removed to meet the established PRLs during excavation, and certify that cleanup goals have been attained. The surveys address both the

radiological and non-radiological contaminants of concern in the soil. Costs for contamination surveys are also shown separately at the alternative estimate level.

Containers/Operating Contractor-Purchased Equipment

This category includes material costs of the site operating contractor's initial purchase of material handling and construction equipment prior to the operations period, including strong-tight containers for final burial. These costs are construed as initial capital acquisition costs and are therefore included in the construction estimate. In cases where annual remediation activities will be performed by a construction contractor (i.e., soil excavation, backfill, on-site disposal cell, and consolidation area), it is assumed that the acquisition of required construction equipment will be the sole responsibility of the contractor, and it will be included in the Contractor Equipment Rental Construction Indirect costs. Periodic replacement costs for this equipment are shown at the operations and maintenance level (if appropriate).

Project Management

This category includes the cost of the operating contractor's home office, project managers, office support, etc. All construction contractors' Construction Direct and Construction Indirect costs and site contractor's purchased equipment are subject to an 8 percent markup.

Construction Management

This category includes the cost of field management support. All Construction Direct and Construction Indirect costs are subject to a 4 percent markup.

K.2.1.5 Engineering Costs

Engineering includes the cost that will be applied to each component estimate for engineering design services.

Architectural/Engineering Subcontract

Engineering costs include development of Title I and II project design drawings and specifications, and providing Title III engineering services. Engineering design costs are applied at 10 percent of total direct and indirect construction costs. Backfill engineering costs are applied at 4 percent. All engineering costs are assumed to be incurred for one year, and will be completed in 1996.

K.2.1.6 Sales Tax

Sales tax is assumed to be 6 percent and is applied to the Construction Direct material cost and Construction Indirect material costs except Contractor Supervision, Payroll Burdens and Benefits, Overhead and Profits, and Bond costs. Sales tax is also applied to Containers/Operating Contractor's Purchased Equipment costs.

K.2.1.7 Remediation Operations and Maintenance Costs

The following sections provide a description of the various cost categories for Remediation Operations and Maintenance. Operations and maintenance is a variable cost that is calculated on an annual basis. All operations and maintenance will commence in the year 1998. Durations will be 22, 25, or 70 years, depending on the component operational strategy. There will be no variation in operating durations for an increase or decrease in worker requirements or shortening of schedule. It is assumed that all costs will be incurred by the Site Operating Contractor, and that each worker will be paid for 8 hours per day regardless of the production need or worker productivity. Therefore, no radiological adjustments to labor are applied. However, employee personal protective equipment costs are also included with system operating and maintenance costs. Personal protective equipment costs are based on the information in Table K.2-2.

Annual Operations Costs

The following breakdown represents the categories costed for annual operations. Depending on the individual component operational strategies, some items may not apply. Reference the Key Assumptions for individual components in Section K.3.0 for further detail.

1. System Operating Personnel: The number of workers required to perform excavation, processing, material handling, or transportation and burial activities depending on component objectives. Costs include all the necessary payroll burdens and benefits (52 percent) that will be incurred by the operating contractor. In addition, 15 percent is added to account for sick time, vacations, etc. Annual costs are dictated by the established operating schedules for each component. A sample calculation for system operating personnel might be:

$$(No.\ of\ workers)\ \left(\frac{8\ hours}{day}\right)\left(\frac{worker}{}\right)\left(\frac{260\ days}{year}\right)\left(\frac{\$16}{hour}\right)(1.52)\ (1.15)$$

   plus worker personal protective clothing requirements. Operating personnel are also marked up an additional 8 percent for the site operating contractor's project management costs.

2. Diesel Fuel: Includes the cost of diesel fuel for operating equipment and/or heating.

3. Sewer Allowance: An allowance for operating on-site sewage treatment plants or otherwise. The allowance attempts to allocate costs to the appropriate component for operation of the centralized sewage treatment plant.

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TABLE K.2-2

PERSONNEL PROTECTION EQUIPMENT (260 DAYS/YR)

Item	Quantity	Unit	Unit Cost	Total Cost
Tyvek or Saranex Suits. Complete suit includes boots, hooded suit, duct tape, gloves. $20.00 each - 4 changes daily.	260	Days	$80	$20,800
HEPA Cartridges - 2 per worker per day.	260	Days	$20	$5,200
Half mask - 1 per worker, replace every 4 months.	3	Each	$60	$180
Mask wash - 7 per worker per month. (Allowance)	1	L.S.	$100	$100
				Total - $26,300 per worker per year

Disposal of suits - 50 per barrel
Barrels $40.00 each (55-gallon drum)
Training - 74 hrs per worker x $25.00
CERCLA (where required) - $1500 per worker

4. Drinking Water (Potable): Includes the cost of providing drinking water to various on-site locations.

5. Chemicals: If applicable, import costs based on chemical usage requirements for a given process (i.e., stabilization, soil washing, groundwater treatment). Depending on the chemical requirements, a sample calculation for the amount of $Na_2 CO_3$ for soil washing might be:

   (235 tons/year) ($140/ton)

6. Process Water: Process water requirements for treatment of soils for stabilization and soil washing processes.

7. Transportation and Burial: Includes the cost to transport materials to staging areas. In the case of Off-Site Disposal, is included the cost of transportation and disposal of materials off site in addition to on-site handling costs.

8. Electrical Consumption: Electrical energy costs at $0.035 per kilowatt-hour (KWH) to operate electrical machinery total load. A demand factor (ratio of the maximum demand on the electrical system to the total connected load of the system) is typically applied at 70-80 percent. Since equipment is usually rated in horsepower (hp), a sample calculation for electrical energy might be:

$$(No.\ of\ hp)\ \left(\frac{0.746\ KW}{1\ hp}\right)\ \left(\frac{24\ hours}{day}\right)\ \left(\frac{260\ days}{year}\right)\ \left(\frac{\$0.035}{kwh}\right)\ (0.70)$$

9. Environmental Monitoring and Contamination Surveys: If applicable, annual analytical and labor costs are included to conduct radiological and non-radiological sampling of soils and localized environmental monitoring. To comply with the Waste Acceptance Criteria at an off-site disposal facility, laboratory sampling will be required prior to off-site shipment of waste. All environmental monitoring and contamination survey operational and maintenance costs are shown separately at the alternative cost level. Localized environmental monitoring costs are shown as a separate category for soil excavation backfill, on-site personnel, and consolidation at the component level.

Annual Maintenance Costs

The following breakdown represents the categories costed for annual maintenance. Depending on the individual component operational and maintenance strategies, some items may not apply. Reference the Key Assumptions for individual components in Section K.3.0 for further detail.

1. System Maintenance Personnel: The number of workers required to perform routine maintenance on equipment. Costs include all the necessary payroll burdens and benefits and sick time, vacations, etc. (52 percent and 15 percent, respectively) that will be incurred by the operating contractor. Annual costs are dictated by the established schedules for each component. (Reference the sample calculation for system operations personnel.)

2. Spare Parts: Includes the cost to carry inventory. For simplicity, the cost for spare parts is included under maintenance and repair costs.

3. Maintenance and Repair: The material and labor cost of providing normal and emergency maintenance on equipment and systems, including the cost of spare parts. Annual maintenance and repair costs are calculated at 5 percent of the initial purchase cost.

Replacement Costs

Replacement costs will vary depending on the component. Equipment will be replaced periodically during its operating life. Replacement costs are calculated at full replacement cost over the operating life of the project. Reference the Key Assumptions for individual components in Section K.3.0 for further detail.

K.2.1.8 Post-Remediation Operations and Maintenance Costs

The following sections provide a description of the various categories required for Post-Remediation Operations and Maintenance. Post-Remediation activities will include long-term monitoring, process facility and support structure decontamination and decommissioning, and miscellaneous operations and maintenance. Activities will start when operations and maintenance activities are completed (removal, treatment, and disposal of waste). Durations will vary depending on the component and its operational and post-remediation strategies. Reference the Key Assumptions for individual components in Section K.3.0 for further detail.

Decontamination and Decommissioning

The costs for decontamination and decommissioning of facilities and equipment are based on historical data and actual take-off. Unit costs are applied where applicable. Salvage value of equipment is not considered in this analysis.

Operations Costs

Annual costs for periodic general up keep of grounds (e.g., mowing, etc.) and will include inspection, sampling, and testing of equipment.

Maintenance Costs

Annual costs for periodic maintenance and repair of equipment.

Replacement Costs

Costs for periodic replacement of equipment based on its expected length of life. Replacement frequency will vary depending on the equipment type and operational requirements.

K.2.1.9 Risk Budget

Risk budget is a specific provision as a separate line item in the estimate to cover cost overruns that may result from incomplete design, unforeseen and unpredictable site conditions, or uncertainties.

K.2.1.10 Contingency

Contingency is a specific provision as a separate line item in the estimate to ensure a balanced cost risk. It is the amount to be added to the base estimate to achieve a 50 percent chance of overrun or underrun.

K.2.2 ALTERNATIVE COST SUMMARY

Table K.2-3 provides an example of an Alternative Cost Summary (in this case for Alternative 2A, Case 2). The Alternative Cost Summary includes the construction, operations and maintenance, post-remediation, and total costs for each component of the selected alternative. Net Present Worth Costs are provided for each component. The Total Escalated Cost is also provided for each alternative. The Alternative Cost Summaries are created by interpolating the costs from the component cost curves (where applicable) at the corresponding media volume.

The Alternative Cost Summaries include both risk budget and contingency at full levels.

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TABLE K.2-3

ALTERNATIVE COST SUMMARY EXAMPLE

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 2A
LOCATION: FEMP
CASE NO. 2

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT2AC2
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	147,712,600	0	718,300	148,430,900	105,847,400
2	OFF-SITE DISPOSAL	565,600	22,950,000	351,600	23,867,200	16,325,000
3	ON-SITE DISPOSAL CELL	339,939,500	0	56,966,000	396,907,500	250,279,600
4	BACKFILL	29,203,700	0	0	29,203,700	20,884,600
5	GMA EXTRACTION (6300 GPM)	10,604,700	27,585,600	1,843,000	40,033,500	27,863,700
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,967,000	25,715,000	392,859,700	253,679,300
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,556,500	121,184,500	0	122,743,000	83,885,000
TOTAL COSTS (ALTERNATIVE 2A - 2)		582,963,300	588,720,200	88,565,000	1,260,268,500	833,508,300
TOTAL ESCALATED COST					3,021,675,800	

Note: All costs includes Risk Budget and Contingency

K.3.0 COMPONENT COST ESTIMATES

As stated previously, all the remedial alternatives are composed of a combination of common remedial components. Alternative costs were developed by applying the volume of contaminated media obtained from modeling to the component cost curves to determine the component cost for each alternative. The following sections outline the major cost elements of each component, identify the key assumptions for each component, provide the generated component cost curve, and present the component cost summaries. In the interest of avoiding excessive document size and a large amount of technical repetition, component cost summaries are provided for 1,500,000 yd^3 and 2,000,000 yd^3 soil volumes only. Great Miami Aquifer Groundwater Extraction and Groundwater and Wastewater Treatment component cost estimates for 6300 and 7500 gpm are provided.

Boundaries between construction, operations and maintenance, and post-remediation are explained in the narrative for each component. It is assumed, however, that annual remediation activities for the soil excavation, backfill, on-site disposal cell, and consolidation area will be performed by a construction contractor, and are therefore subject to the contractor appropriate indirect markups, as well as site operating contractor field support and engineering. Annual costs are estimated in the usual manner as explained in Section K.2.1.7. It is assumed that there will be contractor turnover every two years, and that full mobilization and demobilization costs will be incurred.

K.3.1 SOIL EXCAVATION

The soil excavation component includes construction, operations and maintenance, and post-remediation costs (as applicable) for; verification surveys of potential contamination zones, excavation and segregation of contaminated soils, excavation of on-property perched groundwater zones, excavation control surveys, stormwater controls, certification surveys of excavated areas, pre-treatment of RCRA waste-contaminated soils, and transportation of contaminated soils directly to the on-site disposal cell, consolidation area, or off-site disposal staging facility.

K.3.1.1 Key Assumptions

Construction

1. Excavation activities will start in 1998.

2. Excavation activities will be performed by a construction contractor.

3. Construction activities include initial site preparation (cleaning and grubbing, etc.), the upgrade of all sitewide roadways, and other site improvements, as necessary. It is assumed that the construction of the roadways will not occur in contaminated areas, and therefore no radiological adjustments will be necessary.

4. Included in the contamination survey cost at the alternative level are capital acquisition costs for a mobile laboratory and other analytical equipment to perform sample analysis.

5. Given the commonality of soil excavation to all remediation components, the installation of all gravel and asphalt roadways are placed in the Soil Excavation Component.

6. Labor costs are based on the worker requirements for the various volumes of in situ soils. Costs are estimated for 8 hours per day, 5 days per week, and 52 weeks per year. For the excavated volume, a work force of 11 to 16 must be available during operations. A maintenance staff of two has been included to conduct routine maintenance on equipment.

7. Localized annual environmental monitoring costs are included during the excavation of soils.

8. Soils containing RCRA hazardous waste will be treated at the point of excavation. Vendor-supplied mobile units will be purchased for the treatment of RCRA hazardous waste. After the soils are treated (e.g., the soil no longer contains the RCRA hazardous waste above the remediation levels), they will be dispositioned in accordance with the PRLs. If soils are below PRLs, they will be stockpiled for later use as backfill material. If the soil exceeds PRLs, it will be dispositioned according to the selected remedial alternatives (i.e., disposal cell, consolidation, off-site disposal).

9. It is assumed that heavy earth moving equipment will require full replacement once in 22 years of operation. Since it is difficult to predict when failures will occur, it was decided to show the replacement costs in the eleventh year of operation. Replacement costs for equipment are the sole responsibility of the construction contractor.

Post-Remediation

1. Soil excavation post-remediation activities for the specified volume variations includes the decontamination of earth moving equipment. No salvage value on equipment is considered.

2. D&D activities will start in the year 2020 and will be completed in the same year.

3. D&D activities will be performed by a construction contractor. All costs will therefore be subject to all construction contractor markups.

K.3.1.2 Soil Excavation Cost Curve and Cost Summaries

Figure K.3-1 provides the cost curve for soil excavation. Figures K.3-2 and K.3-3 provide the Soil Excavation Component Cost Summaries for 1,500,000 yd^3 and 2,000,000 yd^3, respectively.

001020

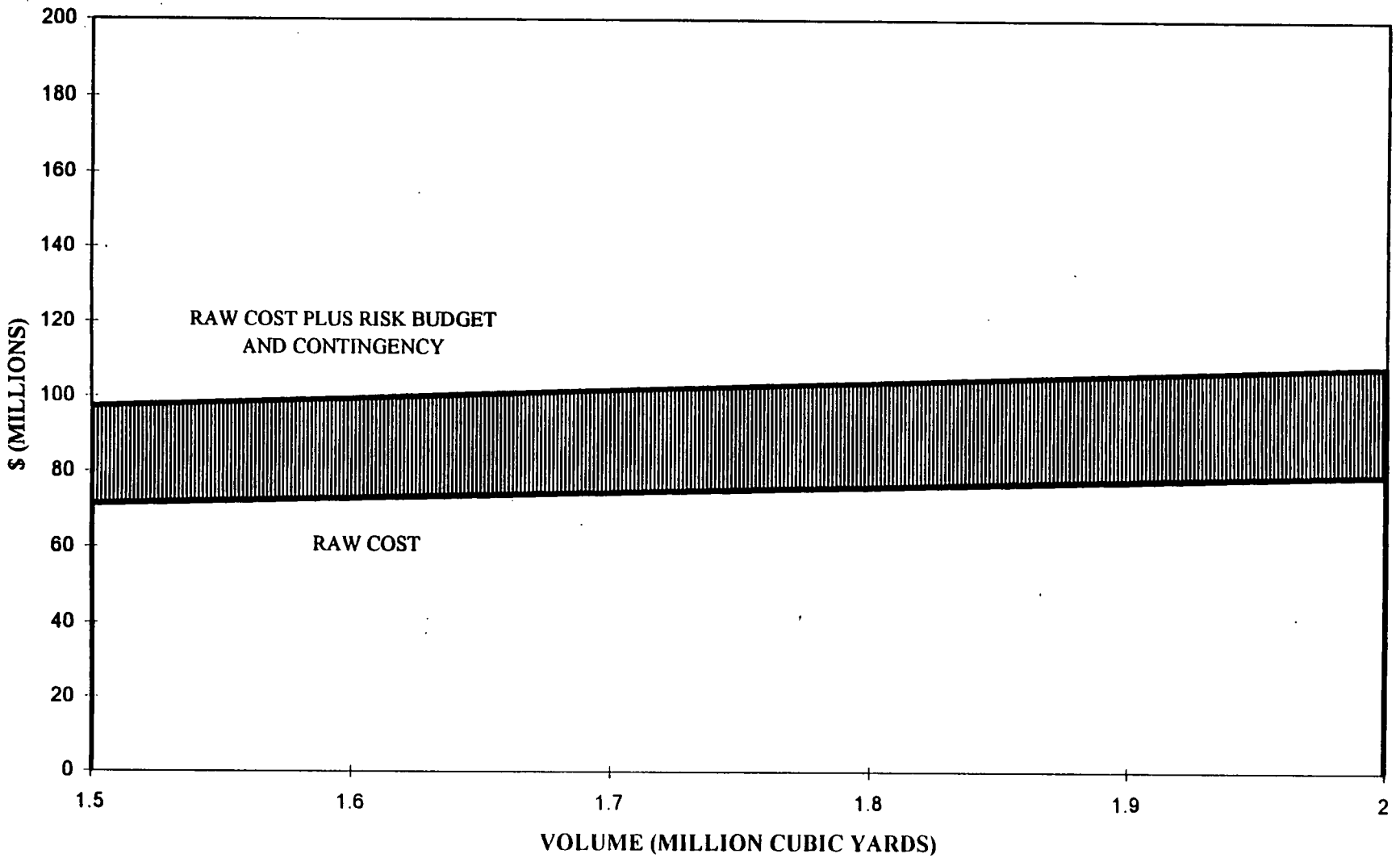

FIGURE K.3-1 - SOIL EXCAVATION COMPONENT COST CURVE

001021

6349

COMPONENT COST SUMMARY

COMPONENT TITLE: SOIL EXCAVATION
LOCATION: FEMP
VOLUME: 1,500,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY J.ADAMS
CHKD. BY B. NEMADE
EST. FILE COMP1B3
REV.#: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	EST. FILE COST	TOTAL COST
	PROCESS BUILDING		8,252	166,300	212,400	378,700
	ROADWAYS		311	6,400	105,000	111,400
	SITE PREPARATION		2,416	49,700	15,500	65,200
CONSTRUCTION DIRECT COSTS			**10,979**	**222,400**	**332,900**	**555,300**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				37,808		37,808
SMALL TOOLS/CONSUMABLES					13,344	13,344
CONTRACTOR EQUIPMENT RENTAL					65,600	65,600
TEMPORARY FACILITIES				4,670	8,674	13,344
TEMPORARY FACILITIES (HOOK-UP)				2,335	4,337	6,672
JOB CLEAN-UP				4,670	8,674	13,344
CONTRACTOR SAFETY				2,335	4,337	6,672
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				13,700		13,700
CERCLA (SITE ACCESS TRAINING)				14,800	25,000	39,800
PAYROLL BURDENS & BENEFITS				157,414		157,414
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				41,412	41,658	83,070
BOND				5,015	5,045	10,061
CONSTRUCTION INDIRECT COSTS				**284,161**	**176,668**	**460,828**
CONSTRUCTION DIRECT & INDIRECT COSTS				**506,600**	**509,600**	**1,016,100**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					1,731,700	1,731,700
PROJECT MANAGEMENT		8.00%				219,800
CONSTRUCTION MANAGEMENT		4.00%				40,600
FIELD SUPPORT						1,992,100
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				101,600
ENGINEERING COSTS						101,600
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					131,700
SUB-TOTAL CONSTRUCTION COSTS						3,241,500
SUB-TOTAL CONSTRUCTION OPERATIONS COSTS						67,774,729
SUB-TOTAL POST-REMEDIATION O&M COSTS						384,400
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)						71,400,629
RISK BUDGET		13.00%				9,282,082
CONTINGENCY		23.30%				16,636,347
TOTAL PROJECT COST						97,319,057

FIGURE K.3-2 - SOIL EXCAVATION COMPONENT COST SUMMARY (1.5 MILLION YD^3)

COMPONENT COST SUMMARY

COMPONENT TITLE: SOIL EXCAVATION
LOCATION: FEMP
VOLUME: 2,000,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY J.ADAMS
CHKD. BY B. NEMADE
EST. FILE COMP1B4
REV.#: 1

CODE	ITEM DESCRIPTION	M/H	LABOR COST	EST. FILE COST	TOTAL COST
	PROCESS BUILDING	8,252	166,300	212,400	378,700
	ROADWAYS	311	6,400	105,000	111,400
	SITE PREPARATION	2,416	49,700	15,500	65,200
CONSTRUCTION DIRECT COSTS		**10,979**	**222,400**	**332,900**	**555,300**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			37,808		37,808
SMALL TOOLS/CONSUMABLES				13,344	13,344
CONTRACTOR EQUIPMENT RENTAL				65,600	65,600
TEMPORARY FACILITIES			4,670	8,674	13,344
TEMPORARY FACILITIES (HOOK-UP)			2,335	4,337	6,672
JOB CLEAN-UP			4,670	8,674	13,344
CONTRACTOR SAFETY			2,335	4,337	6,672
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)			13,700		13,700
CERCLA (SITE ACCESS TRAINING)			14,800	25,000	39,800
PAYROLL BURDENS & BENEFITS			157,414		157,414
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			41,412	41,658	83,070
BOND			5,015	5,045	10,061
CONSTRUCTION INDIRECT COSTS			**284,161**	**176,668**	**460,828**
CONSTRUCTION DIRECT & INDIRECT COSTS			**506,600**	**509,600**	**1,016,100**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.				1,794,100	1,794,100
PROJECT MANAGEMENT	8.00%				224,800
CONSTRUCTION MANAGEMENT	4.00%				40,600
FIELD SUPPORT					2,059,500
ARCHITECTURAL/ENGINEERING SUBCONTRACT	10.00%				101,600
ENGINEERING COSTS					101,600
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				135,420
SUB-TOTAL CONSTRUCTION COSTS					3,312,620
SUB-TOTAL CONSTRUCTION OPERATIONS COSTS					75,733,882
SUB-TOTAL POST-REMEDIATION O&M COSTS					384,400
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)					79,430,902
RISK BUDGET	14.20%				11,279,188
CONTINGENCY	22.20%				17,633,660
TOTAL PROJECT COST					108,343,750

FIGURE K.3-3 - SOIL EXCAVATION COMPONENT COST SUMMARY (2 MILLION YD^3)

K.3.2 SOIL WASHING

The soil washing component includes construction, operations and maintenance, and post-remediation costs (as applicable) for interim storage of contaminated soils, physical/chemical treatment of contaminated soils, interim storage of clean soils, stabilization, containerization, and interim storage of treatment wastes/residues, and transportation of stabilized wastes/residues.

K.3.2.1 Key Assumptions

Construction

1. Construction activities will start in 1998 and be completed in the same year.

2. The construction estimate includes site preparation, facility construction costs, and capital acquisition costs (e.g., purchase of equipment).

3. Construction activities will be performed by a construction contractor. All costs are therefore subject to all construction contractor markups.

4. Equipment capacities are based on processing 20 tons of soil per hour. The sixth-tenths rule is applied to the construction costs for the volume variations as explained in Section K.1.1.3.

5. Construction is assumed to be in a clean area and hence no radiological factors are applied.

Operations and Maintenance

1. O&M activities will commence in 1998 and will continue for 22 years, into 2019.

2. It is assumed that all O&M activities will be performed by the Site Operations Contractor.

3. Operations and maintenance labor costs are based on the worker requirements for soil washing. Costs are estimated for 24 hours per day, 7 days per week, and 365 days per year. Production capacity is based on 66.7 percent efficiency. A worker force of 161 must be available during operations. An additional 27 workers have been identified to operate portable stabilization units for residues from soil washing. It is practical to assume there would be some overlap of responsibilities. For this estimate, however, a conservative approach is taken by not overlapping responsibilities.

   A maintenance staff of 25 has been included to conduct routine maintenance on equipment. Maintenance costs include the cost of labor, repair, and cost of carrying inventory and spare parts for the 22-year period. Annual maintenance is estimated at 5 percent of the original purchase cost of equipment.

4. Power requirements are based on the estimated load with a demand factor of 80 percent. Costs are calculated at 3.5 cents per kilowatt-hour.

5. Chemical reagent costs are based on the usage requirements for soil washing. Chemicals will be received by truck.

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6. It is assumed that 30 percent of the equipment at the interim soil storage facility will require full replacement every 7 years. These costs are included in the "Replacement" column of the Remedial Operations category.

Post-Remediation

1. D&D activities will start in the year 2020 and will be completed in the same year.

2. D&D activities will be performed by a construction contractor. All costs will therefore be subject to all construction contractor markups.

K.3.2.2 Soil Washing Component Cost Curve and Cost Summaries

Figure K.3-4 provides the cost curve for soil washing. Figures K.3-5 and K.3-6 provide the Soil Washing Component Cost Summaries for 1,500,000 yd^3 and 2,000,000 yd^3, respectively.

K.3.3 OFF-SITE DISPOSAL

The off-site disposal component includes construction, operations and maintenance, and post-remediation costs (as applicable) for; construction of a staging facility and rail spurs, loading of bulk soils and stabilized waste into rail cars, transportation to an off-site disposal facility, and waste disposal.

K.3.3.1 Key Assumptions

Construction

1. Construction activities will start in 1998 and be completed in the same year.

2. The construction estimate includes site preparation and facility construction costs, including the addition of 2100 feet of rail spur to accommodate off-site transportation and erection of the staging facility; capital acquisition costs (e.g., purchase of equipment) are included in the construction estimate. Excluded from this estimate are the costs for off-site infra structure improvements and rail car storage yard upgrades. Considering the potential for a greater amount of rail traffic, it is assumed that all improvements, scheduling, and other logistical concerns will be negotiated in the contract.

3. Construction activities will be performed by a construction contractor. All costs are therefore subject to all construction contractor markups.

4. Construction is assumed to be in a clean area, and hence no radiological factors are applied.

Operations and Maintenance

1. O&M activities will commence in 1998 and will continue for 22 years, into 2019.

2. It is assumed that all O&M activities will be performed by the Site Operations Contractor.

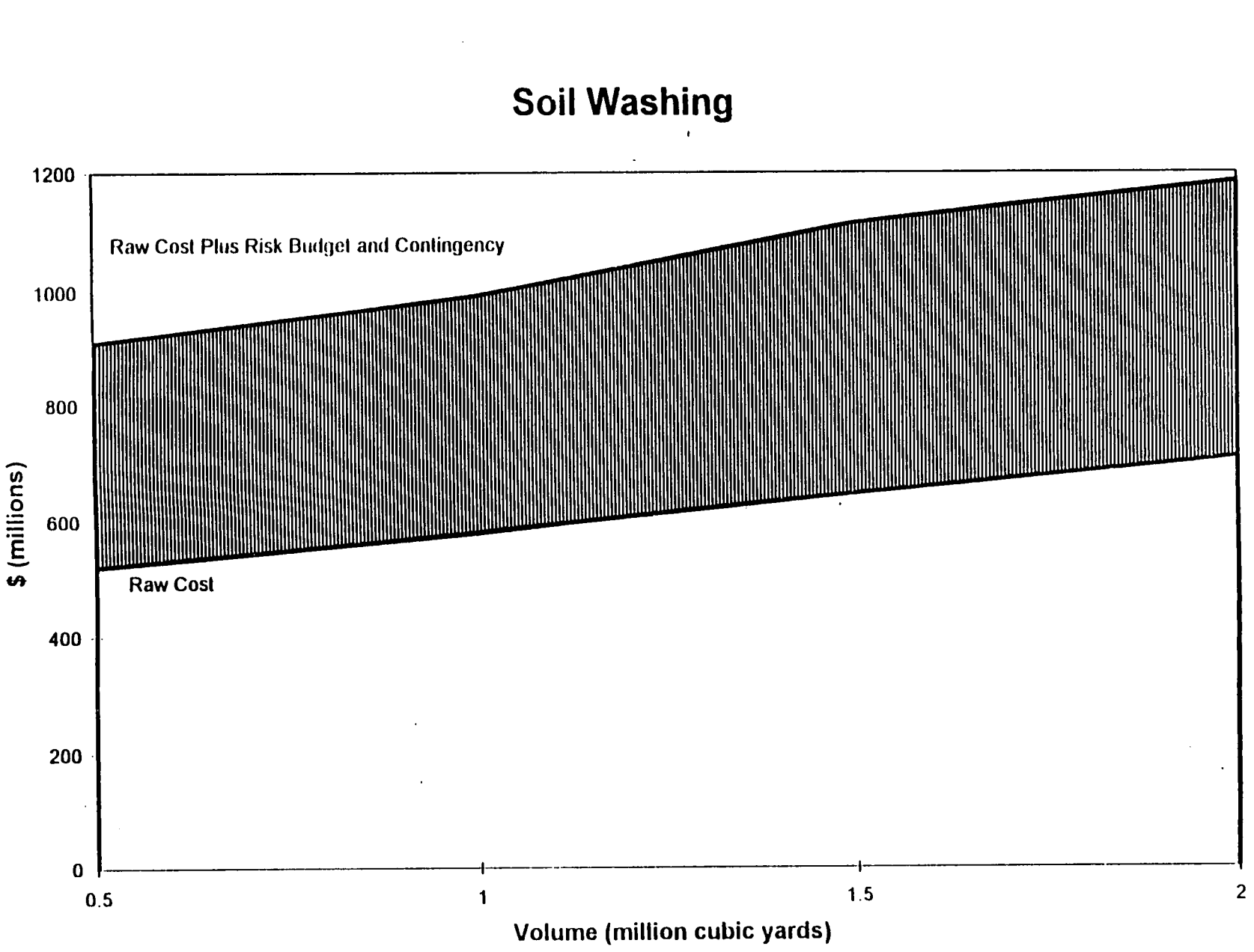

FIGURE K.3-4 - SOIL WASHING COMPONENT COST CURVE

COMPONENT COST SUMMARY

COMPONENT TITLE: SOIL WASHING
LOCATION: FEMP
VOLUME: 1,500,000 CUBIC YARDS

SHEET: 1
DATE: 08-Nov-94
ESTD. BY: D. MALOTT
CHKD. BY: F. FLOYD
EST. FILE: COMP3C1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	PROCESS BUILDING		190,778	3,664,108	5,794,595	9,458,703
	PROCESS ELECTRICAL		21,949	443,317	490,629	933,946
	PROCESS EQUIPMENT		50,109	999,803	957,799	1,957,602
	PROCESS INSTRUMENT		5,565	112,915	281,122	394,037
	PROCESS PIPE		17,105	363,830	393,810	757,640
	ROADWAYS		7,111	168,977	360,140	529,117
	SITE PREPARATION		8,176	167,485	529,138	696,623
CONSTRUCTION DIRECT COSTS			**300,793**	**5,920,435**	**8,807,233**	**14,727,668**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				1,006,474		1,006,474
SMALL TOOLS/CONSUMABLES					355,226	355,226
CONTRACTOR EQUIPMENT RENTAL					891,223	891,223
TEMPORARY FACILITIES				124,329	230,897	355,226
TEMPORARY FACILITIES (HOOK-UP)				62,165	115,448	177,613
JOB CLEAN-UP				124,329	230,897	355,226
CONTRACTOR SAFETY				62,165	115,448	177,613
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)						
CERCLA (SITE ACCESS TRAINING)				433,089	715,000	1,148,089
PAYROLL BURDENS & BENEFITS				4,021,152		4,021,152
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				1,057,872	1,031,524	2,089,396
BOND				128,120	124,929	253,049
CONSTRUCTION INDIRECT COSTS				**7,019,695**	**3,810,593**	**10,830,288**
CONSTRUCTION DIRECT & INDIRECT COSTS				**12,940,100**	**12,617,800**	**25,558,000**
SAMPLING/ WASTE CHARACTERIZATION					78,500	78,500
TRANSPORTATION & BURIAL (HANDLING)						
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					13,593,077	13,593,077
PROJECT MANAGEMENT		8.00%				2,044,600
CONSTRUCTION MANAGEMENT		4.00%				1,022,300
FIELD SUPPORT						**16,738,477**
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				2,555,800
ENGINEERING COSTS						**2,555,800**
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					1,503,285
SUB-TOTAL CONSTRUCTION COSTS						**46,355,562**
SUB-TOTAL REMEDIATION O&M COSTS						587,255,232
SUB-TOTAL POST-REMEDIATION O&M COSTS						13,686,857
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)						**647,297,700**
RISK BUDGET		15.00%				97,094,655
CONTINGENCY		57.00%				368,959,689
TOTAL PROJECT COST						**1,113,352,000**

FIGURE K.3-5 - SOIL WASHING COMPONENT COST SUMMARY (1.5 MILLION YD^3)

COMPONENT COST SUMMARY

COMPONENT TITLE:	SOIL WASHING	SHEET:	1
LOCATION:	FEMP	DATE:	08-Nov-94
VOLUME:	2,000,000 CUBIC YARDS	ESTD. BY:	D. MALOTT
		CHKD. BY	F. FLOYD
		EST. FILE	COMP3D1

CODE	ITEM DESCRIPTION	M/H	LABOR COST	MATERIAL COST	TOTAL COST
	PROCESS BUILDING	244,224	4,668,884	7,270,500	11,939,384
	PROCESS ELECTRICAL	25,122	507,435	574,990	1,082,425
	PROCESS EQUIPMENT	56,825	1,136,134	1,200,933	2,337,067
	PROCESS INSTRUMENT	6,481	131,436	354,617	486,053
	PROCESS PIPE	21,381	454,837	484,904	939,741
	ROADWAYS	7,111	168,977	360,140	529,117
	SITE PREPARATION	9,386	195,882	537,688	733,570
CONSTRUCTION DIRECT COSTS		**370,530**	**7,263,585**	**10,783,772**	**18,047,357**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			1,234,809		1,234,809
SMALL TOOLS/CONSUMABLES				435,815	435,815
CONTRACTOR EQUIPMENT RENTAL				1,041,563	1,041,563
TEMPORARY FACILITIES			152,535	283,280	435,815
TEMPORARY FACILITIES (HOOK-UP)			76,268	141,640	217,908
JOB CLEAN-UP			152,535	283,280	435,815
CONTRACTOR SAFETY			76,268	141,640	217,908
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)					
CERCLA (SITE ACCESS TRAINING)			546,304	820,000	1,366,304
PAYROLL BURDENS & BENEFITS			4,941,198		4,941,198
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			1,299,915	1,253,789	2,553,704
BOND			157,434	151,848	309,282
CONSTRUCTION INDIRECT COSTS			**8,637,267**	**4,552,854**	**13,190,121**
CONSTRUCTION DIRECT & INDIRECT COSTS			**15,900,900**	**15,336,600**	**31,237,500**
SAMPLING/ WASTE CHARACTERIZATION				78,500	78,500
TRANSPORTATION & BURIAL (HANDLING)					
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.				15,839,553	15,839,553
PROJECT MANAGEMENT	8.00%				2,499,000
CONSTRUCTION MANAGEMENT	4.00%				1,249,500
FIELD SUPPORT					**19,666,553**
ARCHITECTURAL/ENGINEERING SUBCONTRACT	10.00%				3,123,750
ENGINEERING COSTS					**3,123,750**
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				1,786,273
SUB-TOTAL CONSTRUCTION COSTS					**55,814,076**
SUB-TOTAL REMEDIATION O&M COSTS					636,791,176
SUB-TOTAL POST-REMEDIATION O&M COSTS					16,404,480
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)					**709,009,700**
RISK BUDGET	17.00%				120,531,649
CONTINGENCY	50.00%				354,504,850
TOTAL PROJECT COST					**1,184,046,200**

FIGURE K.3-6 - SOIL WASHING COMPONENT COST SUMMARY (2 MILLION YD^3)

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Rail Transportation

1. Excavated (bulk) soils, stabilized residues from groundwater treatment, and contaminated demolition rubble will be transported off site by rail car to a representative permitted commercial disposal facility in Utah. The number of shipments (rail cars) per volume scenario are based upon an assumed density of 100 pounds per ft^3 for soil, 35 pounds per ft^3 for demolition rubble, and the use of 55-gallon drums for stabilized residues.

2. Rail car calculations are based on the utilization of 100-ton cars to transport waste materials off site. The net payload per 100 ton car is assumed to be 80 tons. Normally, trains can consist of 50 to 100 cars. Given the fact that there may be limited space available at the FEMP to accommodate the storage of 100 cars, rail shipments are based on a train of 50 cars.

3. Rail cars will be leased through the rail company. It is assumed that maintenance of the rail cars and associated equipment repair will be performed by the operating rail company.

4. Off-site transportation costs include material handling, packaging (loading of rail cars at the FEMP), rail transportation, and disposal costs to an off-site facility. Transportation costs are calculated at $2.50 per rail-mile, and marshalling costs are included at $10 per rail car. Disposal costs are estimated at $8/$ft^3$. An additional work force of 12 is included for miscellaneous handling activities at the FEMP. The estimated distance traveled to the off-site disposal facility is 1900 miles by rail.

5. The off-site shipment of contaminated soils will occur for 22 years.

6. Operations and maintenance labor costs are based on the worker requirements for off-site disposal. Costs are estimated for 8 hours per day, 5 days per week, and 52 weeks per year.

7. The maximum production rate for rail car filling operations is five cars per day. At this rate, demand can be met with the established work force for the given volumes with the exception of the 2 million yd^3 scenario. Overtime or a larger work force will be required. Labor hours have therefore been adjusted accordingly for the 2 million yd^3 option.

8. Maintenance costs include the cost of labor, repair, and cost of carrying inventory and spare parts for the 22-year period. Annual maintenance is estimated at 5 percent of the original purchase cost of equipment.

9. It is assumed that rail car maintenance will be performed by the railroad operating company.

10. It is assumed that the equipment at the staging facility will require full replacement once in 22 years and building roof replacement once in 22 years. These costs are included in the "Replacement" column of the Remedial Operations category.

11. All operations and maintenance activities will be performed by the Site Operating Contractor.

12. Off-site disposal soil volumes not exceeding 50,000 yd^3 total will be transported off-site by truck.

    - Costs are based on unit costs obtained from other transportation studies.

- Truck transportation and disposal costs are applied at the alternative level.
- The unit costs are applied to operations and maintenance costs only.
- A 2 yd^3 strong tight container will be used for truck shipment with each container costing $700. A flat-bed truck will be used to transport the containers.
- Truck transportation costs are based on $648 per yd^3. The cost includes the purchase of containers, packaging and other handling requirements, and transportation.
- Given the smaller quantities, it is assumed that disposal costs are $10 per yd^3.
- No off-site disposal staging facility will be constructed. The central storage facility will be used for staging and packaging soil volumes not exceeding 50,000 yd^3 total.

Post-Remediation

1. Demolition of the Off-Site Disposal Staging Facility will occur in 2020.

2. D&D activities will be performed by a construction contractor. All costs will therefore be subject to all construction contractor markups.

K.3.3.2 Off-Site Disposal Component Cost Curves and Cost Summaries

Figure K.3-7 provides the cost curve for off-site disposal. Figures K.3-8 and K.3-9 provide the Off-Site Disposal Component Cost Summaries for 1,500,000 yd^3 and 2,000,000 yd^3, respectively.

K.3.4 STABILIZATION

The stabilization component includes construction, operations and maintenance, and post-remediation costs (as applicable) for interim storage of contaminated soils, construction of a stabilization facility and process and rail spur, and packaging and transportation of stabilized soils.

K.3.4.1 Key Assumptions

Construction

1. Construction activities will start in 1998 and be completed in the same year.

2. The construction estimate includes site preparation, facility construction costs, and capital acquisition costs (e.g., purchase of equipment).

3. Construction activities will be performed by a construction contractor. All costs are therefore subject to all construction contractor markups.

4. Equipment capacities are based on processing 20 tons of soil per hour. The sixth-tenths rule is applied to the construction costs for the volume variations.

5. The construction cost estimate includes the cost of extending 2100 feet of rail spur to the stabilization plant location.

6. Construction is assumed to be in a clean area, and hence no radiological factors are applied.

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OFF-SITE DISPOSAL (SOILS)

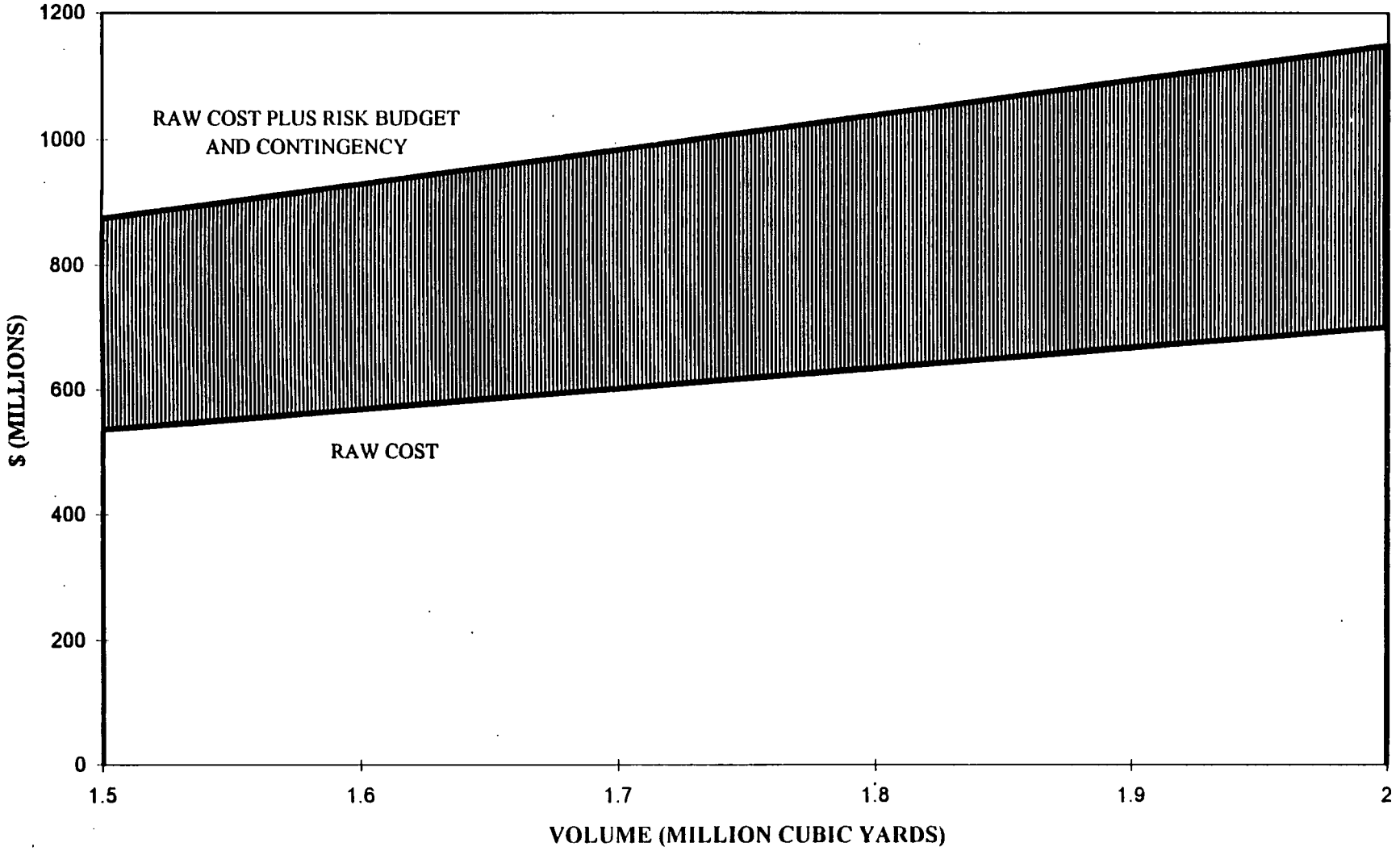


FIGURE K.3-7 - OFF-SITE DISPOSAL COMPONENT COST CURVE

6849

COMPONENT COST SUMMARY

COMPONENT TITLE: OFF-SITE DISPOSAL
LOCATION: FEMP
VOLUME: 1,500,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY B.NEMADE
CHKD. BY F. FLOYD
EST. FILE COMP4CSM
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	PROCESS EQUIPMENT		4,940	89,112	224,426	313,538
	ROADWAYS		1,167	22,590	55,407	77,997
	SITE PREPARATION		38,431	799,603	2,069,218	2,868,821
CONSTRUCTION DIRECT COSTS			**44,538**	**911,305**	**2,349,051**	**3,260,356**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				154,922		154,922
SMALL TOOLS/CONSUMABLES					54,678	54,678
CONTRACTOR EQUIPMENT RENTAL					93,014	93,014
TEMPORARY FACILITIES				19,137	35,541	54,678
TEMPORARY FACILITIES (HOOK-UP)				9,569	17,770	27,339
JOB CLEAN-UP				19,137	35,541	54,678
CONTRACTOR SAFETY				9,569	17,770	27,339
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				45,565	157,800	203,365
CERCLA (SITE ACCESS TRAINING)				22,000		22,000
PAYROLL BURDENS & BENEFITS				619,426		619,426
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				162,957	248,505	411,462
BOND				19,736	30,097	49,833
CONSTRUCTION INDIRECT COSTS				**1,082,018**	**690,717**	**1,772,735**
CONSTRUCTION DIRECT & INDIRECT COSTS				**1,993,300**	**3,039,800**	**5,033,100**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					1,410,100	1,410,100
PROJECT MANAGEMENT		8.00%				515,500
CONSTRUCTION MANAGEMENT		4.00%				201,300
FIELD SUPPORT						2,126,900
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				503,310
ENGINEERING COSTS						503,310
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					250,300
SUB-TOTAL CONSTRUCTION COSTS						7,913,610
SUB-TOTAL REMEDIATION O&M COSTS						523,582,492
SUB-TOTAL POST REMEDIATION COSTS						4,751,600
TOTAL COST (CONSTRUCTION, O&M, POST REMEDIATION)						**536,247,702**
RISK BUDGET		24.00%				128,699,448
CONTINGENCY		39.00%				209,136,604
TOTAL PROJECT COSTS						**874,083,800**

FIGURE K.3-8 - OFF-SITE DISPOSAL COMPONENT COST SUMMARY (1.5 MILLION YD^3)

001012

COMPONENT COST SUMMARY

COMPONENT
TITLE: OFF-SITE DISPOSAL
LOCATION: FEMP
VOLUME: 2,000,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY: B.NEMADE
CHKD. BY F. FLOYD
EST. FILE COMP4DSM
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	PROCESS EQUIPMENT		4,940	89,112	224,426	313,538
	ROADWAYS		1,167	22,590	55,407	77,997
	SITE PREPARATION		38,431	799,603	2,069,218	2,868,821
CONSTRUCTION DIRECT COSTS			**44,538**	**911,305**	**2,349,051**	**3,260,356**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				154,922		154,922
SMALL TOOLS/CONSUMABLES					54,678	54,678
CONTRACTOR EQUIPMENT RENTAL					93,014	93,014
TEMPORARY FACILITIES				19,137	35,541	54,678
TEMPORARY FACILITIES (HOOK-UP)				9,569	17,770	27,339
JOB CLEAN-UP				19,137	35,541	54,678
CONTRACTOR SAFETY				9,569	17,770	27,339
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				45,565	157,800	203,365
CERCLA (SITE ACCESS TRAINING)				22,000		22,000
PAYROLL BURDENS & BENEFITS				619,426		619,426
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				162,957	248,505	411,462
BOND				19,736	30,097	49,833
CONSTRUCTION INDIRECT COSTS				**1,082,018**	**690,717**	**1,772,735**
CONSTRUCTION DIRECT & INDIRECT COSTS				**1,993,300**	**3,039,800**	**5,033,100**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					1,410,100	1,410,100
PROJECT MANAGEMENT		8.00%				515,500
CONSTRUCTION MANAGEMENT		4.00%				201,300
FIELD SUPPORT						2,126,900
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				503,310
ENGINEERING COSTS						**503,310**
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					250,300
SUB-TOTAL CONSTRUCTION COSTS						7,913,610
SUB-TOTAL REMEDIATION O&M COSTS						689,037,760
SUB-TOTAL POST REMEDIATION COSTS						4,751,600
TOTAL COST (CONSTRUCTION, O&M, POST REMEDIATION)						**701,702,970**
RISK BUDGET		22.60%				158,584,871
CONTINGENCY		41.00%				287,698,218
TOTAL PROJECT COSTS						**1,147,986,100**

FIGURE K.3-9 - OFF-SITE DISPOSAL COMPONENT COST SUMMARY (2 MILLION YD^3)

Operations and Maintenance

1. O&M activities will commence in 1998 and will continue for 22 years, into 2019.

2. It is assumed that all O&M activities will be performed by the Site Operating Contractor.

3. Operations and maintenance labor costs are based on the worker requirements for stabilization. Costs are estimated for 24 hours per day, 5 days per week, and 250 days per year. Production capacity is based on 66.7 percent efficiency. A work force of roughly 159 must be available during operations for 2,000,000 yd^3 of in situ soils. A maintenance staff of 24 has been included to conduct routine maintenance on equipment. Maintenance costs include the cost of labor, repair, and cost of carrying inventory and spare parts for the 22-year period. Annual maintenance is estimated at 5 percent of the original purchase cost of equipment.

4. Power requirements are based on the estimated load with a demand factor of 80 percent. Costs are calculated at 3.5 cents per kilowatt-hour.

5. Chemical reagents will be received by train. Chemical costs are based on the usage requirements for stabilization. Cement will be received from off site. The Active Flyash Pile at the FEMP will be used as a source of flyash for the stabilization process; at which only material handling costs are considered.

6. It is assumed that 30 percent of the equipment at the staging facility will require full replacement every 7 years.

Post-Remediation

1. D&D activities will start in the year 2020 and be completed in the same year.

2. D&D activities will be performed by a construction contractor. All costs will therefore be subject to all construction contractor markups.

K.3.4.2 Stabilization Component Cost Curve and Cost Summaries

Figure K.3-10 provides the cost curve for stabilization. Figures K.3-11 and K.3-12 provide the Stabilization Component Cost Summaries for 1,500,000 yd^3 and 2,000,000 yd^3, respectively.

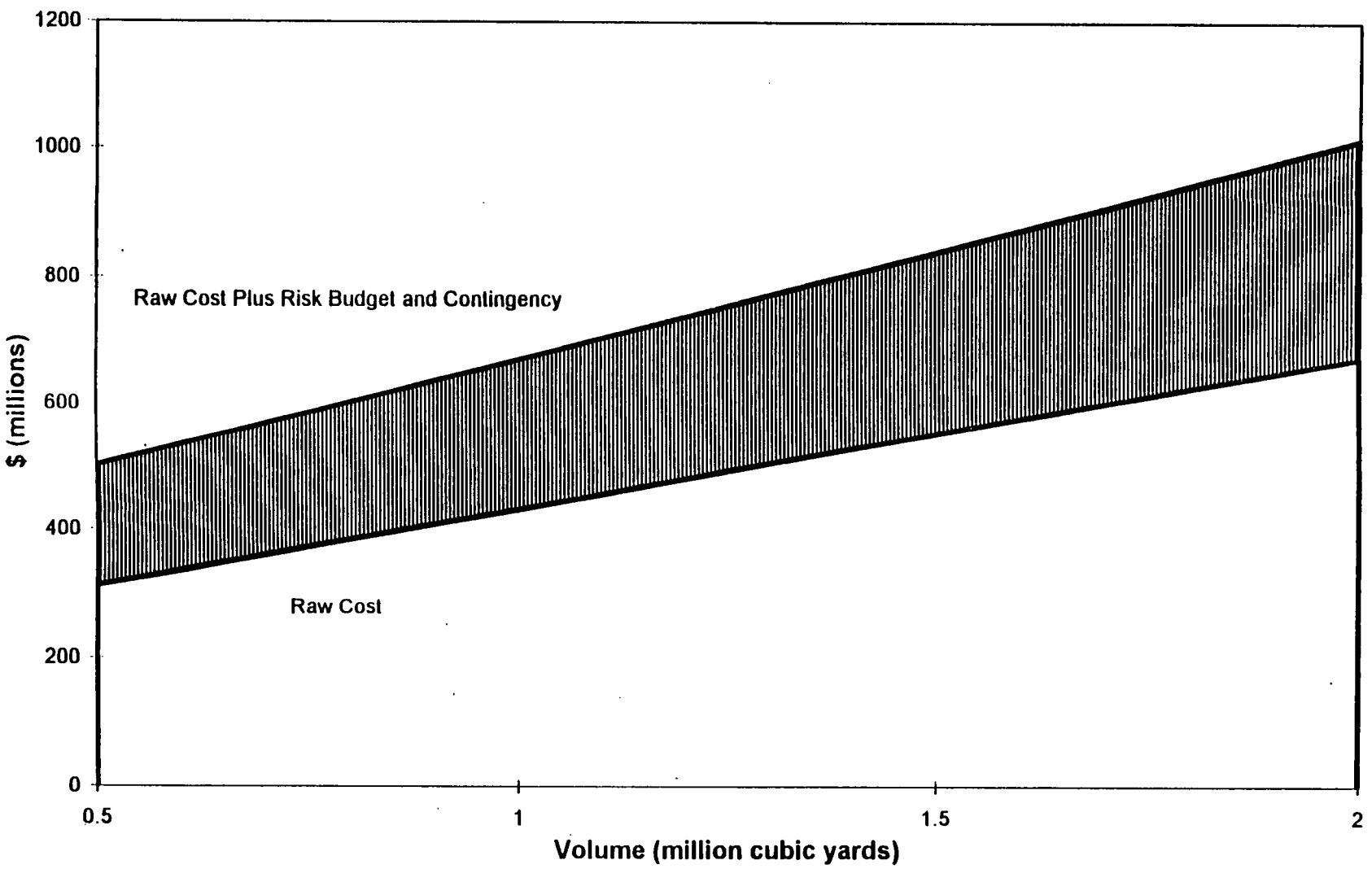


FIGURE K.3-10 - STABILIZATION COMPONENT COST CURVE

002035

6349

COMPONENT COST SUMMARY

COMPONENT TITLE:	STABILIZATION	SHEET:	1
LOCATION:	FEMP	DATE:	08-Nov-94
VOLUME:	1,500,000 CUBIC YARDS	ESTD. BY:	D. MALOTT
		CHKD. BY	F.FLOYD
		EST. FILE	COMP5C

CODE	ITEM DESCRIPTION	M/H	LABOR COST	MATERIAL COST	TOTAL COST
	PROCESS BUILDING	376,248	7,140,916	5,399,440	12,540,356
	PROCESS ELECTRICAL	18,478	370,708	494,873	865,581
	PROCESS EQUIPMENT	35,566	701,474	100,422	801,896
	PROCESS INSTRUMENT	6,016	121,105	729,600	850,705
	PROCESS PIPE	13,454	286,498	188,396	474,894
	ROADWAYS	7,111	145,699	360,140	505,839
	SITE PREPARATION	10,383	384,312	443,186	827,498
CONSTRUCTION DIRECT COSTS		**467,256**	**9,150,712**	**7,716,057**	**16,866,769**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			1,555,621		1,555,621
SMALL TOOLS/CONSUMABLES				549,043	549,043
CONTRACTOR EQUIPMENT RENTAL				934,336	934,336
TEMPORARY FACILITIES			192,165	356,878	549,043
TEMPORARY FACILITIES (HOOK-UP)			96,082	178,439	274,521
JOB CLEAN-UP			192,165	356,878	549,043
CONTRACTOR SAFETY			96,082	178,439	274,521
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)					
CERCLA (SITE ACCESS TRAINING)			482,104	687,500	1,169,604
PAYROLL BURDENS & BENEFITS			6,117,765		6,117,765
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			1,609,443	986,181	2,595,624
BOND			194,921	119,438	314,359
CONSTRUCTION INDIRECT COSTS			**10,536,349**	**4,347,131**	**14,883,479**
CONSTRUCTION DIRECT & INDIRECT COSTS			**19,687,100**	**12,063,200**	**31,750,200**
SAMPLING/ WASTE CHARACTERIZATION				78,500	78,500
TRANSPORTATION & BURIAL (HANDLING)					
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.				17,104,618	17,104,618
PROJECT MANAGEMENT	8.00%				3,914,700
CONSTRUCTION MANAGEMENT	4.00%				1,270,000
FIELD SUPPORT					**22,367,818**
ARCHITECTURAL/ENGINEERING SUBCONTRACT	10.00%				3,175,020
ENGINEERING COSTS					**3,175,020**
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				1,683,777
SUB-TOTAL CONSTRUCTION COSTS					**58,976,815**
SUB-TOTAL REMEDIATION O&M COSTS					480,231,850
SUB-TOTAL POST-REMEDIATION O&M COSTS					13,000,946
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)					**552,209,600**
RISK BUDGET	20.00%				110,441,920
CONTINGENCY	32.00%				176,707,072
TOTAL PROJECT COST					**839,358,600**

FIGURE K.3-11 - STABILIZATION COMPONENT COST SUMMARY (1.5 MILLION YD^3)

001036

COMPONENT COST SUMMARY

COMPONENT TITLE: STABILIZATION
LOCATION: FEMP
VOLUME: 2,000,000 CUBIC YARDS

SHEET: 1
DATE: 08-Nov-94
ESTD. BY: D. MALOTT
CHKD. BY F. FLOYD
EST. FILE COMP5D

CODE	ITEM DESCRIPTION	M/H	LABOR COST	MATERIAL COST	TOTAL COST
	PROCESS BUILDING	445,870	8,461,345	6,277,507	14,738,852
	PROCESS ELECTRICAL	20,667	414,638	530,519	945,157
	PROCESS EQUIPMENT	45,868	901,449	119,252	1,020,701
	PROCESS INSTRUMENT	7,105	143,040	855,000	998,040
	PROCESS PIPE	15,974	340,171	224,656	564,827
	ROADWAYS	7,111	145,699	360,140	505,839
	SITE PREPARATION	10,574	476,539	443,186	919,725
CONSTRUCTION DIRECT COSTS		**553,169**	**10,882,881**	**8,810,260**	**19,693,141**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			1,850,090		1,850,090
SMALL TOOLS/CONSUMABLES				652,973	652,973
CONTRACTOR EQUIPMENT RENTAL				1,078,769	1,078,769
TEMPORARY FACILITIES			228,541	424,432	652,973
TEMPORARY FACILITIES (HOOK-UP)			114,270	212,216	326,486
JOB CLEAN-UP			228,541	424,432	652,973
CONTRACTOR SAFETY			114,270	212,216	326,486
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)					
CERCLA (SITE ACCESS TRAINING)			601,317	857,500	1,458,817
PAYROLL BURDENS & BENEFITS			7,290,353		7,290,353
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			1,917,924	1,140,552	3,058,475
BOND			232,282	138,134	370,415
CONSTRUCTION INDIRECT COSTS			**12,577,587**	**5,141,224**	**17,718,811**
CONSTRUCTION DIRECT & INDIRECT COSTS			**23,460,500**	**13,951,500**	**37,412,000**
SAMPLING/ WASTE CHARACTERIZATION				78,500	78,500
TRANSPORTATION & BURIAL (HANDLING)					
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.				19,967,510	19,967,510
PROJECT MANAGEMENT	8.00%				4,596,600
CONSTRUCTION MANAGEMENT	4.00%				1,496,500
FIELD SUPPORT					**26,139,110**
ARCHITECTURAL/ENGINEERING SUBCONTRACT	10.00%				3,741,200
ENGINEERING COSTS					**3,741,200**
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				1,958,451
SUB-TOTAL CONSTRUCTION COSTS					**69,250,761**
SUB-TOTAL REMEDIATION O&M COSTS					584,611,973
SUB-TOTAL POST-REMEDIATION O&M COSTS					16,794,507
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)					**670,657,200**
RISK BUDGET	21.00%				140,838,012
CONTINGENCY	30.00%				201,197,160
TOTAL PROJECT COST					**1,012,692,400**

FIGURE K.3-12 - STABILIZATION COMPONENT COST SUMMARY (2 MILLION YD³)

K.3.5 CONSOLIDATION

The consolidation component includes construction by an outside contractor for placement of bulk or treated soils, construction of an earthen cover or multilayer cap, and security fencing. Post-remediation will include long-term maintenance, long-term environmental monitoring, and stormwater controls. This component also includes construction of a staging facility/area for cap material.

K.3.5.1 Key Assumptions

Construction

1. Construction activities will start in 1998 and will continue for 22 years into 2019.

2. Construction activities will be performed by a construction contractor. All costs are therefore subject to all construction contractor markups. Annual consolidation area construction will be performed by a construction contractor as well.

3. The area chosen for consolidation will require some site preparation and security fencing prior to the start of operations.

4. The installation of long-term groundwater monitoring wells (numbers as specified) for each volume variation are included in the construction costs.

5. Stormwater collection will be required. Stormwater run-off will also be diverted around the consolidated area to minimize infiltration during and after construction. Ditches and silt fences will be utilized to capture suspended solids in stormwater runoff.

6. Contaminated soils will be disposed of in the consolidation area with an earthen cover with 12 inches of compacted soil, topsoil, and seeding the disturbed area.

7. Stabilized soil will be disposed of in a consolidation area with a multi-layer cap. Cap costs are based on the following assumptions:

   - The site contractor's manpower varied from 10 to 15 as the volume of consolidation pile increased. This additional manpower is for moving stabilized blocks, setting in place geosynthetic materials in the cap, and handling additional construction equipment.
   - This option assumes clean soil will be borrowed from off site for slope protection.

8. The construction contractor's labor costs are based on the worker requirements for consolidation. Production assumes that 600 yd^3 per day of material will be available for the consolidation pile from the 1,000,000 yd^3 volume. It could be easily assumed that worker requirements would increase or decrease proportionately for the other volumes. However, as noted in Section K.2.1.7, workers are paid for a full day's work. Costs are therefore estimated for 8 hours per day, 5 days per week, and 250 days per year. A work force of 12 will be required during operations for the 2,000,000 yd^3 scenario. Maintenance crews have been included to conduct routine maintenance on earth moving equipment. A maintenance crew of five workers is required for the 2,000,000 yd^3 volume. Maintenance costs include

the cost of labor, repair, and cost of carrying inventory and spare parts for the 22-year period. Annual maintenance is estimated at 5 percent of the original purchase cost of equipment.

9. The cost to operate long-term monitoring wells is included in the annual construction cost. Annual long-term monitoring labor costs are based on two man days/well/year. Annual construction costs are distributed at 80 percent of the total monitoring operating costs, and 20 percent for maintenance. It is assumed that 30 percent of the wells will require full replacement during this period. Replacement costs are therefore calculated at 30 percent of the total installation costs and are distributed uniformly throughout the 22-year operating period.

10. Consolidation construction remediation activities include the cost for heavy equipment installations, construction of the consolidation pile, and periodic pumping of long-term monitoring wells.

Operations and Maintenance

1. Construction of the consolidation pile will be performed by a construction contractor.

Post-Remediation

1. Continued sampling of monitoring wells from year 23 to year 120 (an additional 98 years), until the year 2118. It is assumed that environmental monitoring requirements will be re-evaluated at that time.

K.3.5.2 Consolidation Component Cost Curve and Cost Summaries

Figure K.3-13 provides the cost curve for consolidation with an earthen cover. Figures K.3-14 and K.3-15 provide the Consolidation (Earthen Cover) Component Cost Summaries for 1,500,000 yd^3 and 2,000,000 yd^3, respectively.

Figure K.3-16 provides the cost curve for consolidation with a RCRA cover. Figures K.3-17 and K.3-18 provide the Consolidation (RCRA Cover) Component Cost Summaries for 1,500,000 yd^3 and 2,000,000 yd^3, respectively.

K.3.6 ON-PROPERTY DISPOSAL CELL

The on-property disposal cell component includes construction by an outside contractor. Costs also include construction of a staging facility to store capping materials. The engineered cell will be constructed with an appropriate liner and multilayer cap and security fencing. Post-remediation will be done by site operating forces and will include long-term maintenance, long-term environmental monitoring, and stormwater controls.

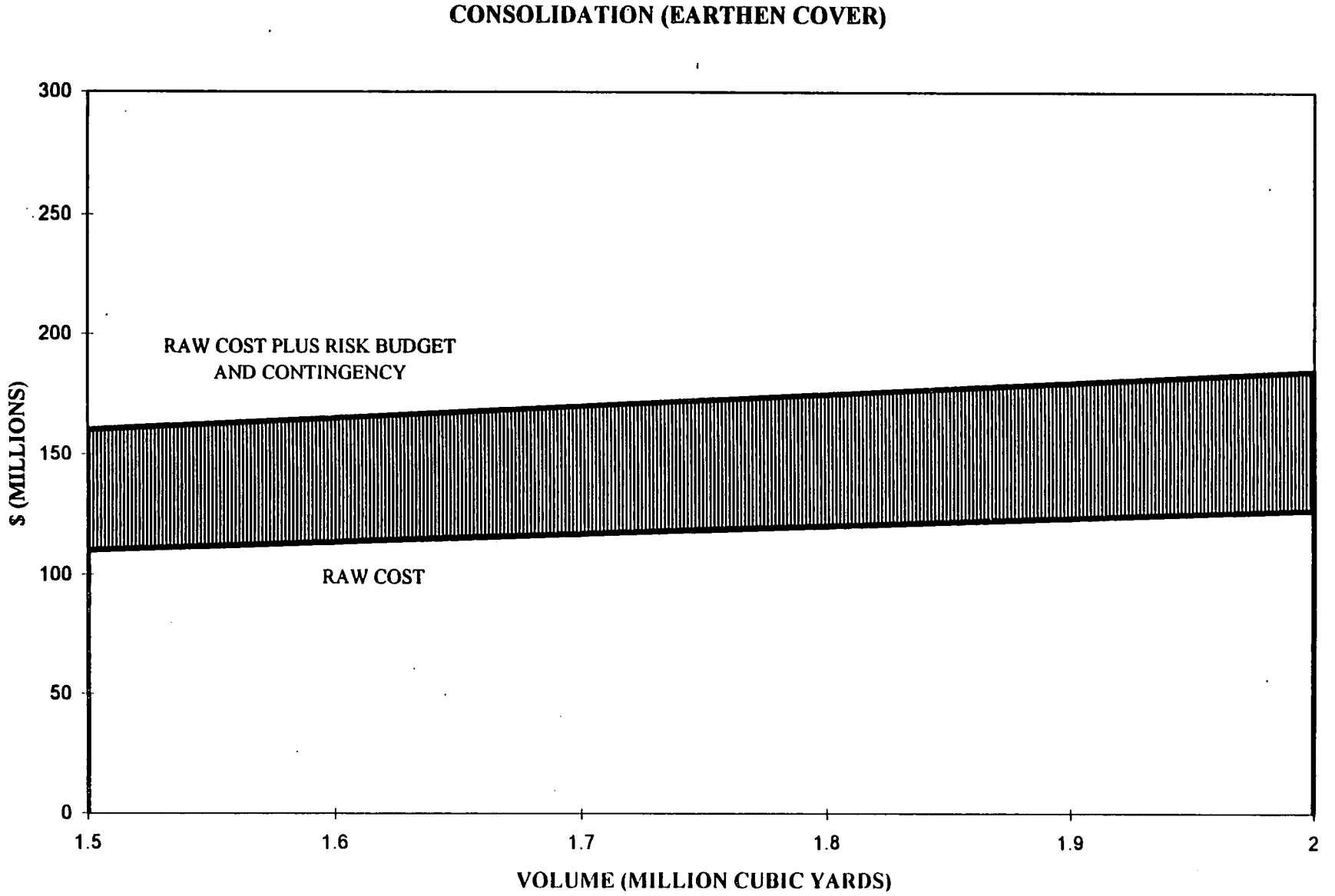


FIGURE K.3-13 - CONSOLIDATION (EARTHEN COVER) COMPONENT COST CURVE

COMPONENT COST SUMMARY

COMPONENT TITLE: CONSOLIDATION (EARTHEN COVER)
LOCATION: FEMP
VOLUME: 1,500,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY: B. NEMADE
CHKD. BY F.FLOYD
EST. FILE COMP6CS1
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	SITE PREPARATION		7,628	152,158	656,973	809,131
CONSTRUCTION DIRECT COSTS			**7,628**	**152,158**	**656,973**	**809,131**
	CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			25,867		25,867
	SMALL TOOLS/CONSUMABLES				9,129	9,129
	CONTRACTOR EQUIPMENT RENTAL				118,440	118,440
	TEMPORARY FACILITIES			3,195	5,934	9,129
	TEMPORARY FACILITIES (HOOK-UP)			1,598	2,967	4,565
	JOB CLEAN-UP			3,195	5,934	9,129
	CONTRACTOR SAFETY			1,598	2,967	4,565
	HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)			7,608	105,200	112,808
	CERCLA (SITE ACCESS TRAINING)			16,000		16,000
	PAYROLL BURDENS & BENEFITS			109,834		109,834
	OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			28,895	81,679	110,574
	BOND			3,499	9,892	13,392
CONSTRUCTION INDIRECT COSTS				**201,289**	**342,143**	**543,432**
CONSTRUCTION DIRECT & INDIRECT COSTS				**353,400**	**999,100**	**1,352,600**
	CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.				920,025	920,025
	PROJECT MANAGEMENT	8.00%				181,800
	CONSTRUCTION MANAGEMENT	4.00%				54,100
FIELD SUPPORT						1,155,925
	ARCHITECTURAL/ENGINEERING SUBCONTRACT	10.00%				135,260
ENGINEERING COSTS						135,260
	SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				109,654
SUB-TOTAL SITE WORKS CONSTRUCTION COSTS						2,753,439
SUB-TOTAL CONSTRUCTION OPERATIONS COSTS						75,347,702
SUB-TOTAL POST-REMEDIATION COSTS						31,982,400
TOTAL COST (CONSTRUCTION, & POST REMEDIATION)						110,083,541
	RISK BUDGET	18.40%				20,255,372
	CONTINGENCY	27.30%				30,052,807
TOTAL PROJECT COST						160,391,700

FIGURE K.3-14 - CONSOLIDATION (EARTHEN COVER) COMPONENT COST SUMMARY (1.5 MILLION YD^3)

COMPONENT COST SUMMARY

COMPONENT TITLE: CONSOLIDATION (EARTHEN COVER)
LOCATION: FEMP
VOLUME: 2,000,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY: B. NEMADE
CHKD. BY F.FLOYD
EST. FILE COMP6DS1
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	SITE PREPARATION		8,533	170,197	795,088	965,285
CONSTRUCTION DIRECT COSTS			**8,533**	**170,197**	**795,088**	**965,285**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				28,933		28,933
SMALL TOOLS/CONSUMABLES					10,212	10,212
CONTRACTOR EQUIPMENT RENTAL					139,046	139,046
TEMPORARY FACILITIES				3,574	6,638	10,212
TEMPORARY FACILITIES (HOOK-UP)				1,787	3,319	5,106
JOB CLEAN-UP				3,574	6,638	10,212
CONTRACTOR SAFETY				1,787	3,319	5,106
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				8,510	105,200	113,710
CERCLA (SITE ACCESS TRAINING)				16,000		16,000
PAYROLL BURDENS & BENEFITS				121,869		121,869
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				32,061	96,251	128,312
BOND				3,883	11,657	15,540
CONSTRUCTION INDIRECT COSTS				**221,978**	**382,279**	**604,257**
CONSTRUCTION DIRECT & INDIRECT COSTS				**392,200**	**1,177,400**	**1,569,500**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					920,025	920,025
PROJECT MANAGEMENT		8.00%				199,200
CONSTRUCTION MANAGEMENT		4.00%				62,800
FIELD SUPPORT						1,182,025
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				156,950
ENGINEERING COSTS						156,950
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					119,369
SUB-TOTAL SITE WORKS CONSTRUCTION COSTS						3,027,844
SUB-TOTAL CONSTRUCTION OPERATIONS COSTS						89,261,187
SUB-TOTAL POST-REMEDIATION COSTS						34,541,760
TOTAL COST (CONSTRUCTION, O&M & POST REMEDIATION)						126,830,791
RISK BUDGET		18.10%				22,956,373
CONTINGENCY		27.60%				35,005,298
TOTAL PROJECT COST						184,792,500

FIGURE K.3-15 - CONSOLIDATION (EARTHEN COVER) COMPONENT COST SUMMARY (2 MILLION YD^3)

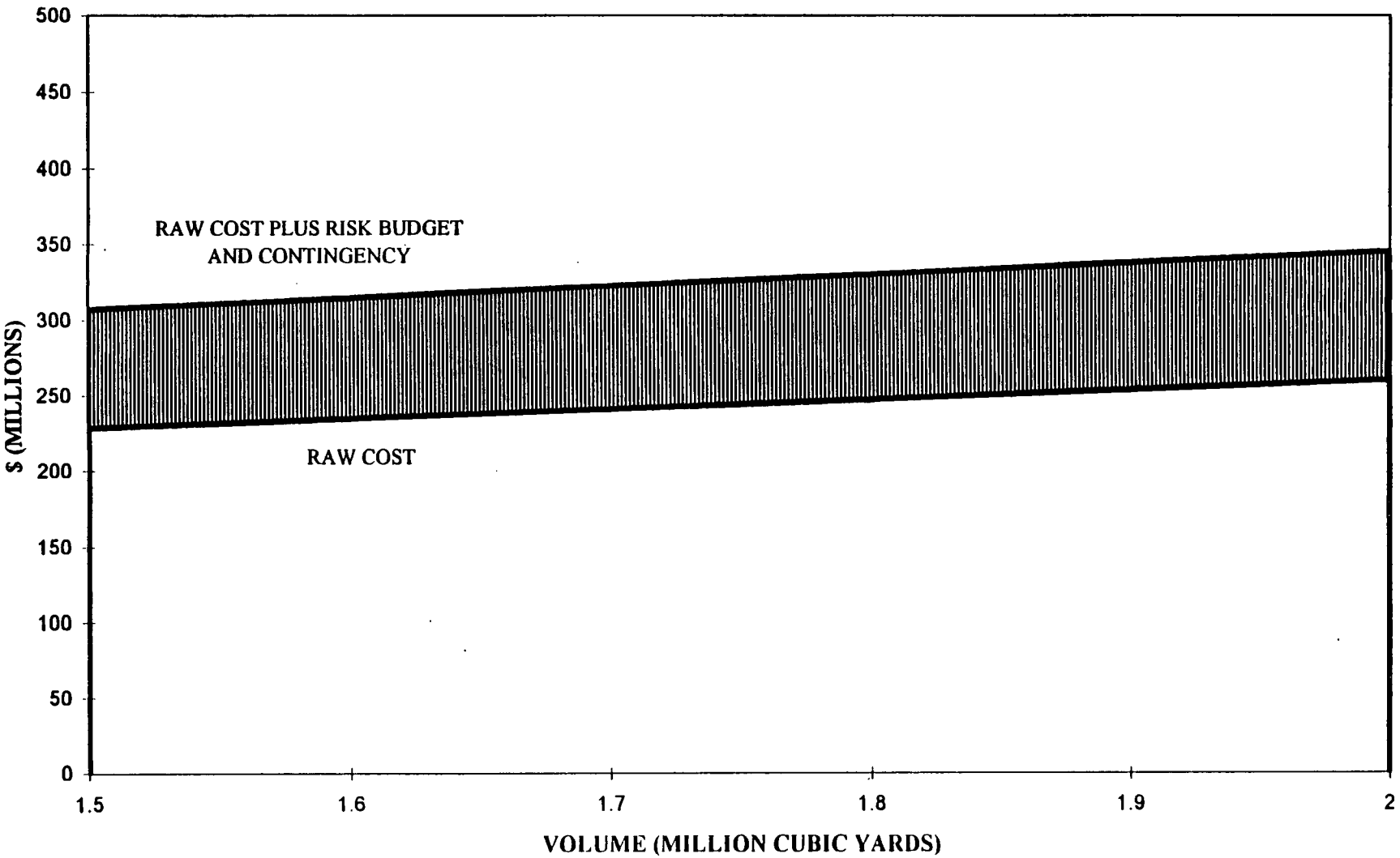


FIGURE K.3-16 - CONSOLIDATION (RCRA COVER) COMPONENT COST CURVE

0010043
6849

COMPONENT COST SUMMARY

COMPONENT TITLE: CONSOLIDATION (RCRA COVER)
LOCATION: FEMP
VOLUME: 1,500,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY: B. NEMADE
CHKD. BY F.FLOYD
EST. FILE CMP6CBS1
REV. #: 1

CODE	ITEM DESCRIPTION	M/H	LABOR COST	MATERIAL COST	TOTAL COST
	PROCESS BUILDING	11,623	232,088	677,173	909,261
	SITE PREPARATION	7,628	152,158	656,973	809,131
CONSTRUCTION DIRECT COSTS		**19,251**	**384,246**	**1,334,146**	**1,718,392**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			65,322		65,322
SMALL TOOLS/CONSUMABLES				23,055	23,055
CONTRACTOR EQUIPMENT RENTAL				118,544	118,544
TEMPORARY FACILITIES			8,069	14,986	23,055
TEMPORARY FACILITIES (HOOK-UP)			4,035	7,493	11,527
JOB CLEAN-UP			8,069	14,986	23,055
CONTRACTOR SAFETY			4,035	7,493	11,527
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)			19,212	105,200	124,412
CERCLA (SITE ACCESS TRAINING)			16,000		16,000
PAYROLL BURDENS & BENEFITS			264,674		264,674
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			69,630	146,331	215,961
BOND			8,433	17,722	26,155
CONSTRUCTION INDIRECT COSTS			**467,478**	**455,809**	**923,287**
CONSTRUCTION DIRECT & INDIRECT COSTS			**851,700**	**1,790,000**	**2,641,700**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.				920,025	920,025
PROJECT MANAGEMENT	8.00%				284,900
CONSTRUCTION MANAGEMENT	4.00%				105,700
FIELD SUPPORT					1,310,625
ARCHITECTURAL/ENGINEERING SUBCONTRACT	10.00%				264,170
ENGINEERING COSTS					264,170
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				152,800
SUB-TOTAL SITE WORKS CONSTRUCTION COSTS					4,369,295
SUB-TOTAL CONSTRUCTION OPERATIONS COSTS					189,045,932
SUB-TOTAL POST-REMEDIATION COSTS					34,936,255
TOTAL COST (CONSTRUCTION, O&M & POST REMEDIATION)					228,351,482
RISK BUDGET	12.00%				27,402,178
CONTINGENCY	22.50%				51,379,083
TOTAL PROJECT COST					307,132,743

FIGURE K.3-17 - CONSOLIDATION (RCRA COVER) COMPONENT COST SUMMARY
(1.5 MILLION YD^3)

COMPONENT COST SUMMARY

COMPONENT TITLE: CONSOLIDATION (RCRA COVER)
LOCATION: FEMP
VOLUME: 2,000,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY: B. NEMADE
CHKD. BY F.FLOYD
EST. FILE CMP6DBS1
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	PROCESS BUILDING		11,623	232,088	677,173	909,261
	SITE PREPARATION		8,533	170,197	795,088	965,285
CONSTRUCTION DIRECT COSTS			**20,156**	**402,285**	**1,472,261**	**1,874,546**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				68,388		68,388
SMALL TOOLS/CONSUMABLES					24,137	24,137
CONTRACTOR EQUIPMENT RENTAL					139,150	139,150
TEMPORARY FACILITIES				8,448	15,689	24,137
TEMPORARY FACILITIES (HOOK-UP)				4,224	7,845	12,069
JOB CLEAN-UP				8,448	15,689	24,137
CONTRACTOR SAFETY				4,224	7,845	12,069
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				20,114	105,200	125,314
CERCLA (SITE ACCESS TRAINING)				16,000		16,000
PAYROLL BURDENS & BENEFITS				276,708		276,708
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				72,796	160,903	233,699
BOND				8,816	19,487	28,304
CONSTRUCTION INDIRECT COSTS				**488,167**	**495,945**	**984,112**
CONSTRUCTION DIRECT & INDIRECT COSTS				**890,500**	**1,968,200**	**2,858,700**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					920,025	920,025
PROJECT MANAGEMENT		8.00%				302,300
CONSTRUCTION MANAGEMENT		4.00%				114,300
FIELD SUPPORT						1,336,625
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				285,870
ENGINEERING COSTS						285,870
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					162,500
SUB-TOTAL SITE WORKS CONSTRUCTION COSTS						4,643,695
SUB-TOTAL CONSTRUCTION OPERATIONS COSTS						218,255,142
SUB-TOTAL POST-REMEDIATION COSTS						37,521,729
TOTAL COST (CONSTRUCTION, O&M & POST REMEDIATION)						260,420,566
RISK BUDGET		10.50%				27,344,159
CONTINGENCY		22.00%				57,292,525
TOTAL PROJECT COST						345,057,250

FIGURE K.3-18 - CONSOLIDATION (RCRA COVER) COMPONENT COST SUMMARY
(2 MILLION YD^3)

K.3.6.1 Key Assumptions

Construction

1. Construction activities will start in 1998 and will continue for 22 years into 2019.

2. Construction activities will be performed by a construction contractor. All costs are therefore subject to all construction contractor markups. Annual on-property disposal cell construction will be performed by a construction contractor as well.

3. The area chosen for the on-property disposal cell will require some extensive cut and fill operations, site preparation, and security fence prior to the start of operations.

4. The installation of long-term groundwater monitoring wells (numbers as specified) for each volume variation are included in the construction costs.

5. Contaminated soil and stabilized wastes will be disposed of in the on-property disposal cell. Costs are based on:

   - The cell will be constructed in modules over 22 years. Each module will have capacity equal to 1/22 of the total soil volume. The berm around the cell is constructed approximately 5 percent size each year till the entire perimeter area is completed in 22 years. Hence it is assumed that the construction contractor has to periodically visit the site and construct the continuing berm before waste placing operation begins each year. The cross section of the typical cell describes the thickness of each layer.

6. The disposal cell will not be completed until the last of the waste has been placed. A portion of the berms and the linear system will be constructed in the northeast corner of the cell footprint. Once this portion of the liner is completed, placement of waste begins and continues until the earthen capping is completed. The new section of liner is then constructed by the construction contractor and placement of waste resumes.

7. The construction contractor's labor costs are based on the worker requirements for on-site disposal. Operations costs are estimated at 8 hours per day; 5 days per week; and 250 days per year. A worker force of 12 will be available during operations for the 2,000,000 yd^3 scenario. A maintenance crew has been included to conduct routine maintenance on earth moving equipment. A crew of 5 workers is required for the 2,000,000 yd^3 volume. Maintenance costs include the cost of labor, repair, and cost of carrying inventory and spare parts for the 22 year period. Annual maintenance is estimated at 5 percent of the original purchase cost of equipment.

8. The cost to operate long-term groundwater monitoring wells is included in the annual construction costs through the last year of construction. Annual long-term monitoring well costs are based on 2 man-days/well/year. Annual long-term monitoring labor costs are based on 2 man-days/well/year. Annual construction costs are distributed at 80 percent of the total monitoring operating costs, and 20 percent for maintenance. It is assumed that 30 percent of the wells will require full replacement during this period. Replacement cost are therefore calculated at 30 percent of the total installation costs and are distributed at 7 year intervals. Long-term environmental monitoring costs past year 22 are included as post-remediation operations and maintenance costs.

Operations and Maintenance

1. Construction of the on-property disposal cell will be performed by a construction contractor.

Post-Remediation

1. Continued sampling of monitoring wells from year 23 to 120 (additional 98 years) until the year 2118. It is assumed that environmental monitoring requirements will be re-evaluated at that time.

2. The cap material staging facility/area will be demolished in the year 2020.

3. Demolition rubble will be packaged appropriately and shipped off site for final disposal.

4. D&D activities will be performed by a construction contractor. All costs will therefore be subject to all construction contractor markups.

K.3.6.2 On-Property Disposal Cell Component Cost Curve and Cost Summaries

Figure K.3-19 provides the cost curve for the on-property disposal cell. Figures K.3-20 and K.3-21 provide the On-Site Disposal Component Cost Summaries for 1,500,000 yd^3 and 2,000,000 yd^3, respectively.

K.3.7 BACKFILL

The backfill component includes construction by an outside contractor. In situ backfilling will include the excavation of backfill from on-property borrow areas or stockpiles, placement of backfill in excavated areas, topsoil placement, and revegetation.

K.3.7.1 Key Assumptions

Construction

1. Construction activities will start in 1998 and will continue for 22 years into 2019.

2. Construction activities will be performed by a construction contractor. All costs are therefore subject to all construction contractor markups. Annual backfilling construction will be performed by a construction contractor as well.

3. Backfilling construction will continue for 22 years for 8 hours per day; 5 days per week; 52 weeks per year. Given the relationship between excavation and backfilling, it is assumed the 2 worker maintenance crew will be available to perform routine maintenance on backfill equipment.

4. Backfill is borrowed from on-property areas or stockpiles to replace the voided space from soil excavation greater than 1.5 feet deep. All other excavated areas (less than 1.5 feet) will be regarded for positive drainage away from on-property disposal areas. Borrowed volumes for the replacement of soils were calculated using "swell" at 27 percent above the in situ volumes.

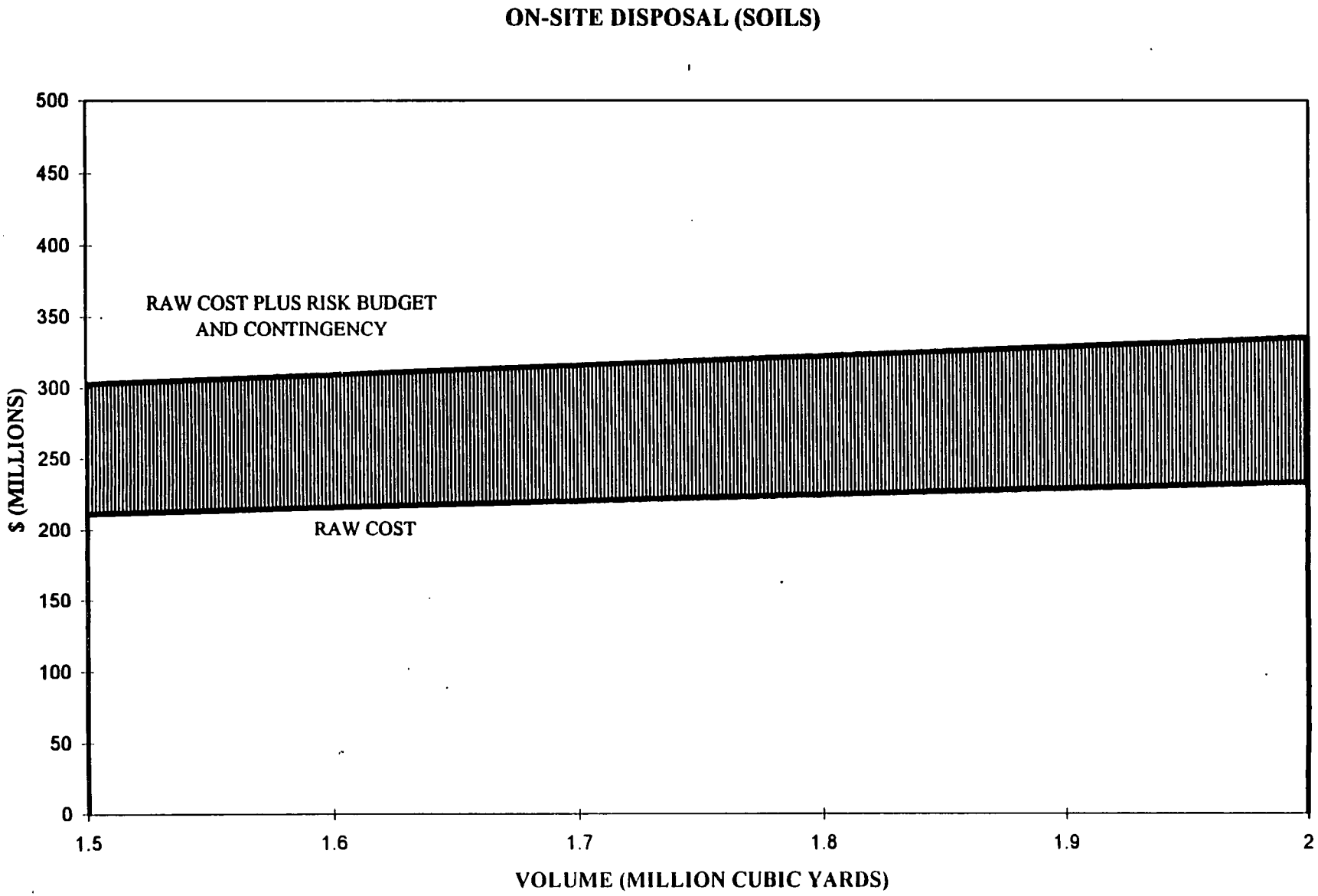


FIGURE K.3-19 - ON-SITE DISPOSAL COMPONENT COST CURVE

0020 78

COMPONENT COST SUMMARY

COMPONENT
TITLE: ON-SITE DISPOSAL CELL (SOILS)
LOCATION: FEMP
VOLUME: 1,500,000 CUBIC YARDS

SHEET: 1
DATE: 01-Nov-94
ESTD. BY: B.NEMADE
CHKD. BY F.FLOYD
EST. FILE COMP7CS1
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	ROADWAYS		2,310	46,217	261,096	307,313
	SITE PREPARATION		22,175	448,147	899,041	1,347,188
CONSTRUCTION DIRECT COSTS			**24,485**	**494,364**	**1,160,137**	**1,654,501**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				84,042		84,042
SMALL TOOLS/CONSUMABLES					29,662	29,662
CONTRACTOR EQUIPMENT RENTAL					199,964	199,964
TEMPORARY FACILITIES				10,382	19,280	29,662
TEMPORARY FACILITIES (HOOK-UP)				5,191	9,640	14,831
JOB CLEAN-UP				10,382	19,280	29,662
CONTRACTOR SAFETY				5,191	9,640	14,831
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				24,718		24,718
CERCLA (SITE ACCESS TRAINING)				24,000		24,000
PAYROLL BURDENS & BENEFITS				342,300		342,300
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				90,051	130,284	220,336
BOND				10,906	15,779	26,685
CONSTRUCTION INDIRECT COSTS				**607,162**	**433,530**	**1,040,692**
CONSTRUCTION DIRECT & INDIRECT COSTS				**1,101,500**	**1,593,700**	**2,695,200**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					1,444,374	1,444,374
PROJECT MANAGEMENT		8.00%				331,200
CONSTRUCTION MANAGEMENT		4.00%				107,800
FIELD SUPPORT						1,883,374
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				269,520
ENGINEERING COSTS						269,520
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					173,500
SUB-TOTAL CONSTRUCTION COSTS						5,021,594
SUB-TOTAL CONSTRUCTION OPERATIONS COSTS						174,501,093
SUB-TOTAL POST REMEDIATION COSTS						32,005,570
TOTAL COST (CONSTRUCTION, O&M & POST-REMEDIATION)						211,528,257
RISK BUDGET		18.30%				38,709,671
CONTINGENCY		24.80%				52,459,008
TOTAL PROJECT COST						**302,696,900**

FIGURE K.3-20 - ON-SITE DISPOSAL COMPONENT COST SUMMARY (1.5 MILLION YD^3)

COMPONENT COST SUMMARY

COMPONENT TITLE: ON-SITE DISPOSAL CELL (SOILS)
LOCATION: FEMP
VOLUME: 2,000,000 CUBIC YARDS

SHEET: 1
DATE: 01-Nov-94
ESTD. BY B.NEMADE
CHKD. BY F.FLOYD
EST. FILE COMP7DS1
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	ROADWAYS		2,566	51,306	374,976	426,282
	SITE PREPARATION		23,189	467,106	925,107	1,392,213
CONSTRUCTION DIRECT COSTS			25,755	518,412	1,300,083	1,818,495
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				88,130		88,130
SMALL TOOLS/CONSUMABLES					31,105	31,105
CONTRACTOR EQUIPMENT RENTAL					235,920	235,920
TEMPORARY FACILITIES				10,887	20,218	31,105
TEMPORARY FACILITIES (HOOK-UP)				5,443	10,109	15,552
JOB CLEAN-UP				10,887	20,218	31,105
CONTRACTOR SAFETY				5,443	10,109	15,552
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				25,921		25,921
CERCLA (SITE ACCESS TRAINING)				24,000		24,000
PAYROLL BURDENS & BENEFITS				358,344		358,344
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				94,272	146,499	240,771
BOND				11,417	17,743	29,160
CONSTRUCTION INDIRECT COSTS				634,744	491,920	1,126,664
CONSTRUCTION DIRECT & INDIRECT COSTS				1,153,200	1,792,000	2,945,200
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					1,444,374	1,444,374
PROJECT MANAGEMENT		8.00%				351,200
CONSTRUCTION MANAGEMENT		4.00%				117,800
FIELD SUPPORT						1,913,374
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				294,520
ENGINEERING COSTS						294,520
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					184,300
SUB-TOTAL CONSTRUCTION COSTS						5,337,394
SUB-TOTAL CONSTRUCTION OPERATIONS COSTS						194,850,151
SUB-TOTAL POST REMEDIATION COSTS						33,547,970
TOTAL COST (CONSTRUCTION, O&M & POST-REMEDIATION)						233,735,515
RISK BUDGET		19.00%				44,409,748
CONTINGENCY		24.30%				56,797,730
TOTAL PROJECT COST						334,943,000

FIGURE K.3-21 - ON-SITE DISPOSAL COMPONENT COST SUMMARY (2 MILLION YD^3)

QC1051

5. No consideration was taken for the two CG&E right-of-ways (138kV, 238 kV) which traverse the on-property borrow area. No cost for pilings/concrete retaining walls, sloping earth, etc., was added.

6. No buildings are constructed by this estimate. Assume the equipment will be left at the excavations or returned to the main site each evening.

7. The estimate assumes that the laboratory within the "Excavation" component can be used for soil classification work. The estimate also assumes that 1/3 more personnel, material, etc. will be required for this work.

8. The estimates assumes that no "post-remedial" expenses will be incurred.

9. The estimate assumes that the seeding and fertilizing of 82,000 yd^2/yr will be performed by the contractor.

Operations and Maintenance

1. Backfilling operations will be performed by a construction contractor.

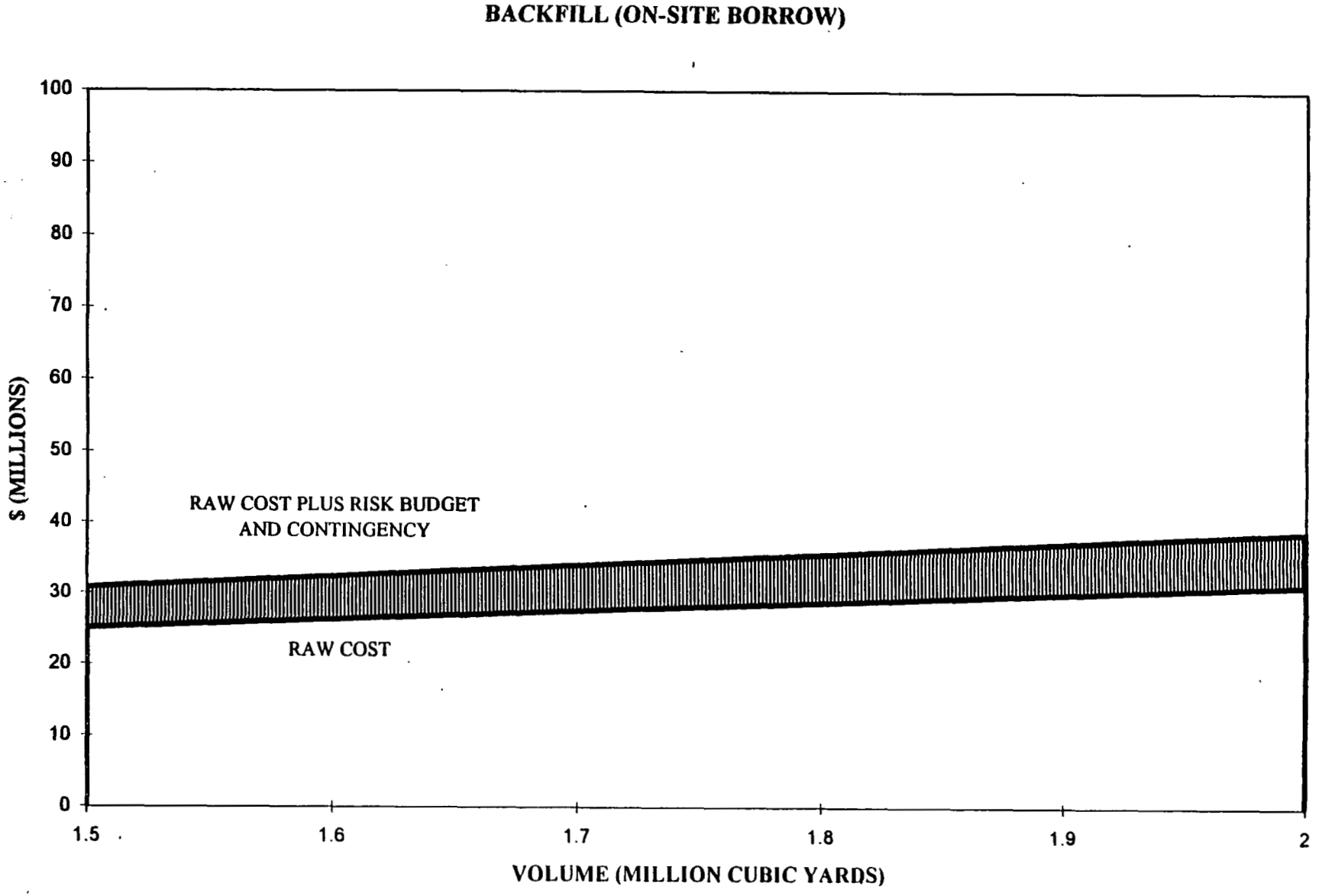
K.3.7.2 Backfill Component Cost Curve and Cost Summaries

Figure K.3-22 provides the cost curve for backfill with on-site borrow material. Figures K.3-23 and K.3-24 provide the Backfill (On-Site Borrow) Component Cost Summaries for 1,500,000 yd^3 and 2,000,000 yd^3, respectively. Figure K.3-25 provides the Backfill (Stockpiled Soils) Component Cost Summary for 500,000 yd^3.

K.3.8 LONG-TERM ENVIRONMENTAL MONITORING

The long-term environmental monitoring component includes construction, operations and maintenance, and post-remediation costs (as applicable) for long-term (post-remediation) monitoring of air, groundwater, and surface water. It includes installation of groundwater monitoring wells and sampling sites, routine sampling and analysis, and long-term maintenance. Site-wide environmental monitoring costs from years 0 through 22 are included at the alternative cost level.

Groundwater monitoring is a support technology used only for those remedial alternatives leaving contaminated media on site (on-property disposal cell and consolidation area). Therefore, the cost of groundwater monitoring is included in the respective component cost estimates. Environmental monitoring costs required during construction are also included in the component cost estimates.



002053

FIGURE K.3-22 - BACKFILL (ON-SITE BORROW) COMPONENT COST CURVE

COMPONENT COST SUMMARY

COMPONENT TITLE: BACKFILL (ON SITE BORROW)
LOCATION: FEMP
VOLUME: 1,500,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY D. MALOTT
CHKD. BY F. FLOYD
EST. FILE COMP8U
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	EXCAVATE BACKFILL & BACKFILL		113,850	2,244,066	1,523,390	3,767,456
	SITE PREPARATION		1,595	32,824	2,618,000	2,650,824
CONSTRUCTION DIRECT COSTS			**115,445**	**2,276,890**	**4,141,390**	**6,418,280**
	CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			387,071		387,071
	SMALL TOOLS/CONSUMABLES				136,613	136,613
	CONTRACTOR EQUIPMENT RENTAL				8,857,046	8,857,046
	TEMPORARY FACILITIES			47,815	88,799	136,613
	TEMPORARY FACILITIES (HOOK-UP)			23,907	44,399	68,307
	JOB CLEAN-UP			47,815	88,799	136,613
	CONTRACTOR SAFETY			23,907	44,399	68,307
	HEALTH PHYSICS (RAD. CHECK INTERRUPTION)		28,861	569,223		569,223
	CERCLA (SITE ACCESS TRAINING)		8,360	164,882	313,500	478,382
	PAYROLL BURDENS & BENEFITS			1,841,585		1,841,585
	OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			484,479	1,234,345	1,718,824
	BOND			58,676	149,493	208,169
CONSTRUCTION INDIRECT COSTS				**3,649,359**	**10,957,394**	**14,606,753**
CONSTRUCTION DIRECT & INDIRECT COSTS				**5,926,200**	**15,098,800**	**21,025,000**
	PROJECT MANAGEMENT	8.00%				1,682,000
	CONSTRUCTION MANAGEMENT	4.00%				841,000
FIELD SUPPORT						2,523,000
	ARCHITECTURAL/ENGINEERING SUBCONTRACT	3.00%				630,750
ENGINEERING COSTS						630,750
	SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				822,900
SUB-TOTAL CONSTRUCTION COSTS						25,001,650
SUB-TOTAL REMEDIATION O&M COSTS						0
SUB-TOTAL POST-REMEDIATION O&M COSTS						0
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)						**25,001,650**
	RISK BUDGET	12.10%				3,025,200
	CONTINGENCY	11.30%				2,825,186
TOTAL PROJECT COST						**30,852,000**

FIGURE K.3-23 - BACKFILL (ON-SITE BORROW) COMPONENT COST SUMMARY
(1.5 MILLION YD^3)

COMPONENT COST SUMMARY

COMPONENT TITLE: BACKFILL (ON SITE BORROW)
LOCATION: FEMP
VOLUME: 2,000,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY: D. MALOTT
CHKD. BY: F. FLOYD
EST. FILE: COMP8S
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	EXCAVATE BACKFILL, BACKFILL		148,577	2,930,125	1,928,454	4,858,579
	SITE PREPARATION		1,595	32,824	2,618,000	2,650,824
CONSTRUCTION DIRECT COSTS			**150,172**	**2,962,949**	**4,546,454**	**7,509,403**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				503,701		503,701
SMALL TOOLS/CONSUMABLES					177,777	177,777
CONTRACTOR EQUIPMENT RENTAL					11,555,796	11,555,796
TEMPORARY FACILITIES				62,222	115,555	177,777
TEMPORARY FACILITIES (HOOK-UP)				31,111	57,778	88,888
JOB CLEAN-UP				62,222	115,555	177,777
CONTRACTOR SAFETY				31,111	57,778	88,888
HEALTH PHYSICS (RAD. CHECK INTERRUPTION)			37,543	740,737		740,737
CERCLA (SITE ACCESS TRAINING)			8,800	173,627	330,000	503,627
PAYROLL BURDENS & BENEFITS				2,375,194		2,375,194
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				624,859	1,526,102	2,150,961
BOND				75,677	184,828	260,505
CONSTRUCTION INDIRECT COSTS				**4,680,462**	**14,121,168**	**18,801,630**
CONSTRUCTION DIRECT & INDIRECT COSTS				**7,643,400**	**18,667,600**	**26,311,000**
PROJECT MANAGEMENT		8.00%				2,104,900
CONSTRUCTION MANAGEMENT		4.00%				1,052,400
FIELD SUPPORT						3,157,300
ARCHITECTURAL/ENGINEERING SUBCONTRACT		3.00%				789,330
ENGINEERING COSTS						789,330
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					1,017,400
SUB-TOTAL CONSTRUCTION COSTS						31,275,030
SUB-TOTAL REMEDIATION O&M COSTS						0
SUB-TOTAL POST-REMEDIATION O&M COSTS						0
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)						31,275,030
RISK BUDGET		12.10%				3,784,279
CONTINGENCY		11.90%				3,721,729
TOTAL PROJECT COST						**38,781,000**

FIGURE K.3-24 - BACKFILL (ON-SITE BORROW) COMPONENT COST SUMMARY
(2 MILLION YD^3)

001055

COMPONENT COST SUMMARY

COMPONENT TITLE: BACKFILL (STOCKPILED SOILS)
LOCATION: FEMP
VOLUME: 500,000 CUBIC YARDS

SHEET: 1
DATE: 02-Nov-94
ESTD. BY J.ADAMS
CHKD. BY B. NEMADE
EST.FILE: STOCKPILE
REV.#: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	EST.FILE: COST	TOTAL COST
	STOCKPILED BACKFILL		10,354	213,000	100	213,100
CONSTRUCTION DIRECT COSTS			**10,354**	**213,000**	**100**	**213,100**
	CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			36,210		36,210
	SMALL TOOLS/CONSUMABLES				12,780	12,780
	CONTRACTOR EQUIPMENT RENTAL				86,000	86,000
	TEMPORARY FACILITIES			4,473	8,307	12,780
	TEMPORARY FACILITIES (HOOK-UP)			2,237	4,154	6,390
	JOB CLEAN-UP			4,473	8,307	12,780
	CONTRACTOR SAFETY			2,237	4,154	6,390
	HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)			13,100		13,100
	CERCLA (SITE ACCESS TRAINING)		592	12,000	12,000	24,000
	PAYROLL BURDENS & BENEFITS			149,619		149,619
	OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			39,361	12,222	51,583
	BOND			4,767	1,480	6,247
CONSTRUCTION INDIRECT COSTS			**10,946**	**268,477**	**149,403**	**417,880**
CONSTRUCTION DIRECT & INDIRECT COSTS				**481,500**	**149,500**	**631,000**
	PROJECT MANAGEMENT	8.00%				50,500
	CONSTRUCTION MANAGEMENT	4.00%				25,200
FIELD SUPPORT						**75,700**
	ARCHITECTURAL/ENGINEERING SUBCONTRACT					0
ENGINEERING COSTS						0
	SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				8,100
SUB-TOTAL CONSTRUCTION COSTS (FOR 2 YRS.)						**714,800**
SUB-TOTAL CONSTRUCTION COSTS (FOR REMAINING 20 YRS.)						**7,148,000**
SUB-TOTAL POST-REMEDIATION O&M COSTS						**0**
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)						**7,862,800**
	RISK BUDGET	16.70%				1,313,088
	CONTINGENCY	31.10%				2,445,331
TOTAL PROJECT COST						**11,621,200**

FIGURE K.3-25 - BACKFILL (STOCKPILED SOILS) COMPONENT COST SUMMARY
(500,000 YD^3)

K.3.9 GREAT MIAMI AQUIFER GROUNDWATER EXTRACTION

The Great Miami Aquifer extraction component includes construction, operations and maintenance, and post-remediation costs (as applicable) for installation of extraction wells, pumps, piping, and groundwater monitoring. Depending on the cleanup requirements, life cycle costing is provided for pumping at 6300 and 7500 gpm, for 30 and 75 years, respectively. There are a total of 28 wells required for the 6300 gpm (20 ppb) extraction scenario, and 31 wells for the 7500 gpm (3 ppb). Each well requires its own separate control building. The tally in each case includes 5 existing wells from the South Plume area. Therefore, a total of 23 and 26 (6300 and 7500 gpm, respectively) new wells will need to be installed. The operations and maintenance costs from 1995 through 1999 are for operating the South Plume wells only. All wells will operate the remaining 25 years for the 6300 gpm case and 70 years for 7500 gpm.

K.3.9.1 Key Assumptions

Construction

1. Construction activities will start in 1997 and will be completed in 1999.

2. Construction activities will be performed by a construction contractor. All costs are therefore subject to all construction contractor markups.

3. Construction cost includes the requirements for drilling wells and the installation of materials and equipment, as necessary.

4. The control building construction costs include site clearing, equipment, and other systems installation (i.e., electrical, instrumentation, roadways, site preparation).

5. Additional roadways have been costed for access to well and control building areas.

6. Construction is assumed to take place in clean areas and hence no radiological factors are applied.

Operations and Maintenance

1. O&M activities for the existing South Plume wells will start in 1995 and continue for 30 or 75 years. O&M activities for new wells will start in 2000 and will continue for 25 or 70 years in which groundwater will be pumped and treated at the Great Miami Aquifer groundwater treatment facility.

2. It is assumed that all O&M activities will be performed by the Site Operating Contractor.

3. Great Miami Aquifer extraction operations and maintenance labor costs are based on the worker requirements 10 man-days per well annually. Worker requirements are distributed at 30 percent for operations and 70 percent for maintenance. Electrical costs are calculated at 24 hours per day; 7 days per week; and 365 days per year with an anticipated demand factor of 60 to 80 percent of the total connected load. Energy costs are estimated at 3.5 cents per kilowatt-hour. Annual maintenance is estimated at 5 percent of the original purchase cost for the equipment amortized equally over the 30 or 70 year period. It is

assumed that 30 percent of the Great Miami Aquifer extraction wells and equipment will require replacement every 10 years. Replacement costs are estimated at 30 percent of the total installation cost and they too are distributed uniformly over the 30 or 70 year period.

Post-Remediation

1. Well abandonment and control buildings demolition activities will start and will finish in the year 2026 for the 6300 gpm equipment, and 2070 for 7500 gpm. Each extraction well will be plugged in accordance with all regulations.

2. Demolition rubble will be packaged appropriately and shipped off site for final disposal.

3. D&D activities and final seeding will be performed by a construction contractor. All costs will therefore be subject to all contractor markups.

K.3.9.2 Great Miami Aquifer Groundwater Extraction Component Cost Curve and Cost Summaries

Figure K.3-26 provides the cost curve for Great Miami Aquifer groundwater extraction. Figures K.3-27 and K.3-28 provide the Great Miami Aquifer Groundwater Extraction Component Cost Summaries for clean-up to 20 ppb and 3 ppb, respectively.

K.3.10 GROUNDWATER AND WASTEWATER TREATMENT

The groundwater and wastewater treatment component includes construction, operations and maintenance, and post-remediation costs (as applicable) for carbon adsorption and ion exchange treatment of Great Miami Aquifer groundwater, stabilization, packaging and transportation of treatment wastes and spent media, and discharge of treated water. In addition, costs are also provided for construction, operations and maintenance, and post-remediation of the AWWT Slurry Dewatering Facility, periodic sediment removal and liner repair of the existing storm water retention basin (SWRB), and operations and maintenance and post-remediation of the AWWT Phases I and II facility. The groundwater treatment facility cost analysis is based on a design of 6300 and 7500 gpm of treatment capacity depending on clean-up levels. The operating period for the 6300 gpm facility will be 25 years while the 7500 gpm facility will operate for 70 years.

K.3.10.1 Key Assumptions

Construction

1. Construction activities will start in 1997 and be completed in 1999.

2. Construction activities will be performed by a construction contractor. All costs are therefore subject to all construction contractor markups.

3. Construction activities for the Great Miami Aquifer Groundwater Treatment Facility and AWWT Slurry Dewatering Facility will only consist of site clearing and grubbing, as well as, the erection of the building and installation of equipment. Portable stabilization units are purchased for treating spent media from the groundwater treatment process.

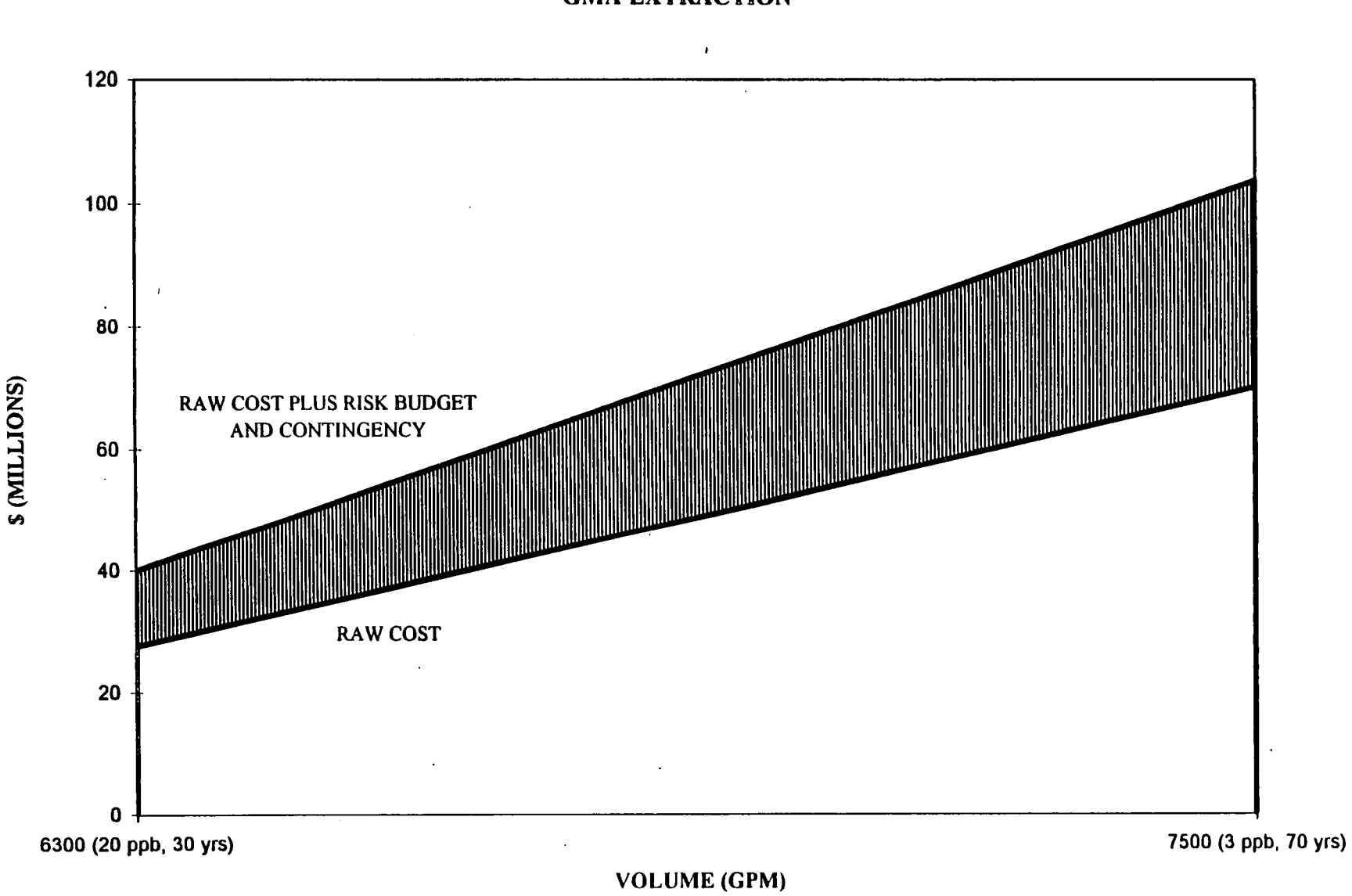


FIGURE K.3-26 - GREAT MIAMI AQUIFER GROUNDWATER EXTRACTION
COMPONENT COST CURVE

00400

COMPONENT COST SUMMARY

COMPONENT TITLE: GMA EXTRACTION (20 PPB)
LOCATION: FEMP
VOLUME: 6,300 GPM

SHEET: 1
DATE: 02-Nov-94
ESTD. BY D. MALOTT
CHKD. BY F. FLOYD
EST. FILE COMP11F
REV.#: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	EST. FILE COST	TOTAL COST
	PROCESS BUILDING					
	PROCESS ELECTRICAL		9,288	187,571	59,539	247,110
	PROCESS INSTRUMENT		692	14,171	1,450	15,621
	ROADWAYS		3,723	77,500	99,000	176,500
	SITE PREPARATION		43,719	913,116	1,349,595	2,262,711
CONSTRUCTION DIRECT COSTS			**57,422**	**1,192,358**	**1,509,584**	**2,701,942**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				202,701		202,701
SMALL TOOLS/CONSUMABLES					71,541	71,541
CONTRACTOR EQUIPMENT RENTAL					95,900	95,900
TEMPORARY FACILITIES				25,040	46,502	71,541
TEMPORARY FACILITIES (HOOK-UP)				12,520	23,251	35,771
JOB CLEAN-UP				25,040	46,502	71,541
CONTRACTOR SAFETY				12,520	23,251	35,771
CERCLA (SITE ACCESS TRAINING)					99,500	99,500
PAYROLL BURDENS & BENEFITS				764,492		764,492
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				201,120	172,443	373,563
BOND				24,358	20,885	45,243
CONSTRUCTION INDIRECT COSTS				**1,267,790**	**599,775**	**1,867,565**
CONSTRUCTION DIRECT & INDIRECT COSTS				**2,460,100**	**2,109,400**	**4,569,500**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					1,428,764	1,428,764
PROJECT MANAGEMENT		8.00%				479,900
CONSTRUCTION MANAGEMENT		4.00%				182,800
FIELD SUPPORT						2,091,464
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				456,950
ENGINEERING COSTS						**456,950**
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					200,700
SUB-TOTAL CONSTRUCTION COSTS						**7,318,614**
SUB-TOTAL REMEDIATION O&M COSTS						19,037,831
SUB-TOTAL POST-REMEDIATION O&M COSTS						1,271,945
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)						**27,628,390**
RISK BUDGET		22.20%				6,133,503
CONTINGENCY		22.70%				6,271,645
TOTAL PROJECT COST						**40,033,500**

FIGURE K.3-27 - GREAT MIAMI AQUIFER GROUNDWATER EXTRACTION COMPONENT COST SUMMARY (20 PPB)

COMPONENT COST SUMMARY

COMPONENT TITLE: GMA EXTRACTION (3 PPB)
LOCATION: FEMP
VOLUME: 7,500 GPM

SHEET: 1
DATE: 02-Nov-94
ESTD. BY: D. MALOTT
CHKD. BY F. FLOYD
EST. FILE COMP11E
REV.#: 1

CODE	ITEM DESCRIPTION	M/H	LABOR COST	MATERIAL COST	TOTAL COST
	PROCESS BUILDING				
	PROCESS ELECTRICAL	9,569	192,549	57,293	249,842
	PROCESS EQUIPMENT				
	PROCESS INSTRUMENT	740	15,125	1,300	16,425
	ROADWAYS	3,519	72,400	99,000	171,400
	SITE PREPARATION	49,218	1,024,357	1,501,049	2,525,406
CONSTRUCTION DIRECT COSTS		63,046	1,304,431	1,658,642	2,963,073
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			221,753		221,753
SMALL TOOLS/CONSUMABLES				78,266	78,266
CONTRACTOR EQUIPMENT RENTAL				99,900	99,900
TEMPORARY FACILITIES			27,393	50,873	78,266
TEMPORARY FACILITIES (HOOK-UP)			13,697	25,436	39,133
JOB CLEAN-UP			27,393	50,873	78,266
CONTRACTOR SAFETY			13,697	25,436	39,133
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)			0	0	0
CERCLA (SITE ACCESS TRAINING)				99,500	99,500
PAYROLL BURDENS & BENEFITS			836,349		836,349
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			220,024	188,003	408,027
BOND			26,647	22,769	49,417
CONSTRUCTION INDIRECT COSTS			1,386,953	641,057	2,028,010
CONSTRUCTION DIRECT & INDIRECT COSTS			2,691,400	2,299,700	4,991,100
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.				1,665,390	1,665,390
PROJECT MANAGEMENT	8.00%				532,500
CONSTRUCTION MANAGEMENT	4.00%				199,600
FIELD SUPPORT					2,397,490
ARCHITECTURAL/ENGINEERING SUBCONTRACT	10.00%				499,110
ENGINEERING COSTS					499,110
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				225,259
SUB-TOTAL CONSTRUCTION COSTS					8,112,959
SUB-TOTAL REMEDIATION O&M COSTS					60,530,538
SUB-TOTAL POST-REMEDIATION O&M COSTS					1,316,926
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)					69,960,423
RISK BUDGET	20.50%				14,341,887
CONTINGENCY	27.60%				19,309,077
TOTAL PROJECT COST					103,611,400

FIGURE K.3-28 - GREAT MIAMI AQUIFER GROUNDWATER EXTRACTION COMPONENT COST SUMMARY (3 PPB)

001061

4. Construction is assumed to take place in a clean area and hence no radiological factors are applied.

Operations and Maintenance

1. The Great Miami Aquifer Groundwater Treatment Facility will operate for 25 or 70 years. O&M activities will start in 2000 During the O&M remediation activities, the SWRB will be kept in service. Periodic maintenance and repair of the liner and the activities associated with the removal of sediments will take place.

2. The AWWT Phases I and II will operate from the year 1995 through 2019.

3. The AWWT Slurry Dewatering Facility will operate from the years 2000 through 2019.

4. It is assumed that all plant operations and other activities will be performed by the Site Operating Contractor.

5. Operational labor (process and material handling) costs for the Groundwater Treatment Facility are calculated based on the worker requirements of 115 shifts per week. Power requirements are calculated for 24 hours per day; 7 days per week; and 365 days per year of operation. Electrical costs are based on a demand factor of 80 percent of the total connected load. Electrical energy costs are then estimated at 3.5 cents per kilowatt-hour. Other costs for operations include the receival and handling of chemicals, spent media disposal, personnel protective clothing, CERCLA training, etc.

6. Maintenance labor costs for the Groundwater Treatment Facility are calculated for 98 shifts per week. Added are repair materials and spare part inventory estimated at 5 percent of the original purchase cost for the equipment, and is distributed uniformly over the 30 year period.

7. It is assumed that 40 to 50 percent of the Groundwater Treatment Facility operating equipment will require replacement every 25 years. Replacement costs are estimated at 30 percent of the initial installation cost. The costs are distributed uniformly over the 25 year period.

8. Labor costs for operations and maintenance for the AWWT Phases I and II and Slurry Dewatering System are based on worker requirements of 27 and 3, respectively.

Post-Remediation

1. Post-remediation will consist of the demolition and decommissioning of all plant buildings and equipment, as well as, the disposal of demolition rubble. It is assumed that 25 percent of facility structures and equipment is considered contaminated and will require size reduction, wrapping, boxing, and transport to an acceptable disposal facility. The remaining 75 percent is considered clean and it is assumed these materials can be disposed at a local landfill.

2. At the completion of soil remedial operations in 2020, the SWRB will be remediated, contaminated soils will be removed, and the basin will be backfilled.

K.3.10.2 Groundwater and Wastewater Treatment Component Cost Curve and Cost Summaries

Figure K.3-29 provides the cost curve for groundwater and wastewater treatment. Figures K.3-30 and K.3-31 provide the Groundwater and Wastewater Treatment Component Cost Summaries for groundwater clean-up to 20 ppb and 3 ppb, respectively.

K.3.11 CENTRAL STORAGE FACILITY

The Central Storage Facility will be constructed as a tension support structure (40,000 ft^2) and will be used to temporarily store contaminated soils until final disposal. The cost of a wheel washing facility is also included with the purpose of washing the transport vehicle wheels that exit the process area.

K.3.11.1 Key Assumptions

Construction

1. Construction activities will start in 1997. It is assumed the construction period for the Central Storage Facility will take approximately 9 months to complete.

2. Construction activities will be performed by a construction contractor. All costs are therefore subject to all construction contractor markups.

3. Construction is assumed to take place in a clean area and hence no radiological factors are applied.

Operations and Maintenance

1. O&M activities will commence in 1998 and will continue for 22 years, into 2019.

2. It is assumed that all O&M activities will be performed by the Site Operating Contractor.

K.3.11.2 Central Storage Facility Cost Summary

Figure K.3-32 provides the Central Storage Facility Cost Summary.

GROUNDWATER AND WASTEWATER TREATMENT

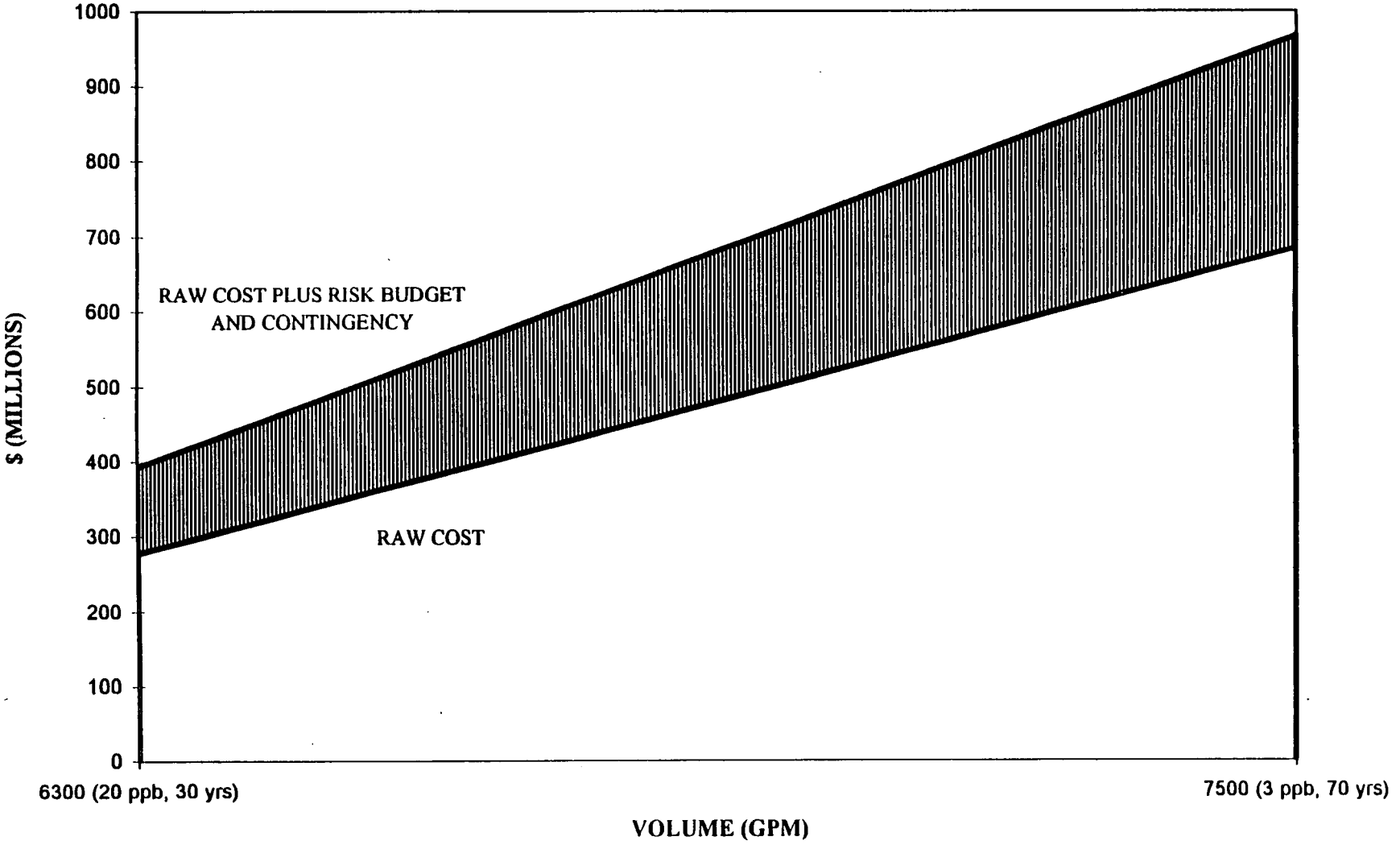


FIGURE K.3-29 - GROUNDWATER AND WASTEWATER TREATMENT
COMPONENT COST CURVE

001064

6349

COMPONENT COST SUMMARY

COMPONENT TITLE: GROUNDWATER & WASTEWATER TREATMENT
LOCATION: FEMP
VOLUME: 6300 GPM

SHEET: 1
DATE: 02-Nov-94
ESTD. BY J. ADAMS
CHKD. BY B.NEMADE
EST. FILE COMP13GT
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	EST. FILE COST	TOTAL COST
	GROUNDWATER TREATMENT		151,034	3,043,000	5,489,200	8,532,200
	AWWT SLURRY DEWATERING SYSTEM		36,972	741,400	689,900	1,431,300
CONSTRUCTION DIRECT COSTS			**188,006**	**3,784,400**	**6,179,100**	**9,963,500**
	CONTRACTOR SUPERVISION (OFFICE OVERHEAD)			643,348		643,348
	SMALL TOOLS/CONSUMABLES				227,064	227,064
	CONTRACTOR EQUIPMENT RENTAL				626,100	626,100
	TEMPORARY FACILITIES			79,472	147,592	227,064
	TEMPORARY FACILITIES (HOOK-UP)			39,736	73,796	113,532
	JOB CLEAN-UP			79,472	147,592	227,064
	CONTRACTOR SAFETY			39,736	73,796	113,532
	HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)			224,000		224,000
	CERCLA (SITE ACCESS TRAINING)			128,100	134,550	262,650
	PAYROLL BURDENS & BENEFITS			2,609,498		2,609,498
	OVERHEAD & PROFIT (GC & SUBCONTRACTORS)			686,499	684,863	1,371,362
	BOND			83,143	82,945	166,087
CONSTRUCTION INDIRECT COSTS				**4,613,004**	**2,198,296**	**6,811,301**
CONSTRUCTION DIRECT & INDIRECT COSTS				**8,397,400**	**8,377,400**	**16,774,800**
	SAMPLING/ WASTE CHARACTERIZATION				1,420,700	1,420,700
	CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.				9,506,900	9,506,900
	PROJECT MANAGEMENT	8.00%				2,216,200
	CONSTRUCTION MANAGEMENT	4.00%				671,000
FIELD SUPPORT						13,814,800
	ARCHITECTURAL/ENGINEERING SUBCONTRACT	10.00%				1,677,480
ENGINEERING COSTS						1,677,480
	SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.				1,026,983
SUB-TOTAL CONSTRUCTION COSTS						33,294,063
SUB-TOTAL REMEDIATION O&M COSTS						225,805,898
SUB-TOTAL POST-REMEDIATION O&M COSTS						18,147,500
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)						277,247,461
	RISK BUDGET	19.1%				52,954,265
	CONTINGENCY	22.6%				62,657,926
TOTAL PROJECT COST						392,859,700

FIGURE K.3-30 - GROUNDWATER AND WASTEWATER TREATMENT COMPONENT COST SUMMARY (20 PPB)

0C1065

COMPONENT COST SUMMARY

COMPONENT TITLE: GROUNDWATER & WASTEWATER TREATMENT
LOCATION: FEMP
VOLUME: 7500 GPM

SHEET: 1
DATE: 02-Nov-94
ESTD. BY J. ADAMS
CHKD. BY B.NEMADE
EST. FILE COMP13GS1
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	EST. FILE COST	TOTAL COST
	GROUNDWATER TREATMENT		167,815	3,381,100	6,099,100	9,480,200
	AWWT SLURRY DEWATERING SYSTEM		41,080	823,800	766,600	1,590,400
CONSTRUCTION DIRECT COSTS			**208,895**	**4,204,900**	**6,865,700**	**11,070,600**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				714,833		714,833
SMALL TOOLS/CONSUMABLES					252,294	252,294
CONTRACTOR EQUIPMENT RENTAL					695,700	695,700
TEMPORARY FACILITIES				88,303	163,991	252,294
TEMPORARY FACILITIES (HOOK-UP)				44,151	81,996	126,147
JOB CLEAN-UP				88,303	163,991	252,294
CONTRACTOR SAFETY				44,151	81,996	126,147
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				248,900		248,900
CERCLA (SITE ACCESS TRAINING)				142,300	149,500	291,800
PAYROLL BURDENS & BENEFITS				2,899,438		2,899,438
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				762,775	760,965	1,523,740
BOND				92,381	92,161	184,542
CONSTRUCTION INDIRECT COSTS				**5,125,535**	**2,442,594**	**7,568,129**
CONSTRUCTION DIRECT & INDIRECT COSTS				**9,330,400**	**9,308,300**	**18,638,700**
SAMPLING/ WASTE CHARACTERIZATION					1,578,500	1,578,500
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					10,563,200	10,563,200
PROJECT MANAGEMENT		8.00%				2,462,400
CONSTRUCTION MANAGEMENT		4.00%				745,500
FIELD SUPPORT						15,349,600
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				1,863,870
ENGINEERING COSTS						1,863,870
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCHASED EQUIP.					1,141,092
SUB-TOTAL CONSTRUCTION COSTS						**36,993,262**
SUB-TOTAL REMEDIATION O&M COSTS						**627,841,217**
SUB-TOTAL POST-REMEDIATION O&M COSTS						**18,989,500**
TOTAL COSTS (CONSTRUCTION, REMEDIATION O&M, POST-REMEDIATION O&M)						**683,823,979**
RISK BUDGET		18.5%				126,507,436
CONTINGENCY		23.0%				157,279,515
TOTAL PROJECT COST						**967,610,900**

FIGURE K.3-31 - GROUNDWATER AND WASTEWATER TREATMENT
COMPONENT COST SUMMARY (3 PPB)

COMPONENT COST SUMMARY

COMPONENT TITLE: CENTRAL STORAGE FACILITY
LOCATION: FEMP

SHEET: 1
DATE: 01-Nov-94
ESTD. BY: B.NEMADE
CHKD. BY F.FLOYD
EST. FILE PO20CSFS
REV. #: 1

CODE	ITEM DESCRIPTION		M/H	LABOR COST	MATERIAL COST	TOTAL COST
	SITE WORKS		10,458	251,060	407,714	658,774
	CENTRAL STORAGE FACILITY		16,040	370,103	908,324	1,278,427
	WHEEL WASH FACILITY		2,721	65,185	138,239	203,424
CONSTRUCTION DIRECT COSTS			**29,219**	**686,348**	**1,454,277**	**2,140,625**
CONTRACTOR SUPERVISION (OFFICE OVERHEAD)				116,679		116,679
SMALL TOOLS/CONSUMABLES					41,181	41,181
CONTRACTOR EQUIPMENT RENTAL					102,267	102,267
TEMPORARY FACILITIES				14,413	26,768	41,181
TEMPORARY FACILITIES (HOOK-UP)				7,207	13,384	20,590
JOB CLEAN-UP				14,413	26,768	41,181
CONTRACTOR SAFETY				7,207	13,384	20,590
HEALTH PHYSICS (RAD. CHECK INTERRUPTION/PROT. CLOTHING)				102,952		102,952
CERCLA (SITE ACCESS TRAINING)				28,000		28,000
PAYROLL BURDENS & BENEFITS				508,154		508,154
OVERHEAD & PROFIT (GC & SUBCONTRACTORS)				133,684	151,022	284,706
BOND				16,191	18,290	34,481
CONSTRUCTION INDIRECT COSTS				**948,899**	**393,063**	**1,341,963**
CONSTRUCTION DIRECT & INDIRECT COSTS				**1,635,200**	**1,847,300**	**3,482,600**
CONTAINERS/OPERATING CONTRACTOR PURCHASED EQUIP.					158,000	158,000
PROJECT MANAGEMENT		8.00%				291,200
CONSTRUCTION MANAGEMENT		4.00%				139,300
FIELD SUPPORT						**588,500**
ARCHITECTURAL/ENGINEERING SUBCONTRACT		10.00%				348,260
ENGINEERING COSTS						**348,260**
SALES TAX	6.00% OF FIELD MATERIAL AND OPER. CONTRACTOR PURCASED EQUIP.					110,200
SUB-TOTAL CONSTRUCTION COSTS						**4,529,560**
SUB-TOTAL REMEDIATION O&M COSTS						18,285,500
SUB-TOTAL POST REMEDIATION COSTS						2,168,800
TOTAL COST (CONSTRUCTION, O&M, POST REMEDIATION)						**24,983,860**
RISK BUDGET		10.50%				2,623,305
CONTINGENCY		26.40%				6,595,739
TOTAL PROJECT COSTS						**34,202,900**

FIGURE K.3-32 - CENTRAL STORAGE FACILITY COST SUMMARY

001057

K.4.0 ALTERNATIVE COST ESTIMATES

This section provides the remedial alternative cost summaries and life-cycle cost breakdowns generated for each remedial alternative case.

K.4.1 ALTERNATIVE COST SUMMARIES

Using the costs developed from the component cost estimates established for the 1.5 and 2.0 million cubic yard volumes, alternative costs were determined through mathematical interpolation or extrapolation for each component's construction, O&M, post-remediation, present worth, and escalated costs.

Construction, O&M, and post-remediation total costs were adjusted for each component to include the risk budget and contingency. Annual cash flows at the component level were also adjusted to include the affects of risk budget and contingency. The Present Worth Analysis was then developed using the Real Discount Rate of 2.8 percent on the adjusted annual cash flows. Net Present Worth costs for each component are then summarized to provide the total Net Present Worth costs for each alternative. Total escalated costs are based on using a rate of 3.7 percent compounded annually as noted in Section K.1.1.6. and are shown as a one line entry for each alternative.

Life cycle costs are presented for each alternative. An attempt was made to spread the extrapolated dollar amounts based on the specified planning periods for each component. Please note that actual Net Present Worth costs were not determined from the Alternative Cost Summaries Life Cycle costs, since the distribution of costs may not be as accurately portrayed as they were at the component level.

The following sections provide the cost summaries and life-cycle cost tables for each remedial alternative and its associated cases.

K.4.1.1 Alternative 1 Cost Summaries and Life-Cycle Costs

Figures K.4-1 and K.4-2 provide the cost summaries for Alternative 1, Cases 1 and 2, respectively. Tables K.4-1 and K.4-2 provide the life-cycle costs for Alternative 1, Cases 1 and 2, respectively.

K.4.1.2 Alternative 2A Cost Summaries and Life-Cycle Costs

Figures K.4-3 and K.4-4 provide the cost summaries for Alternative 2A, Cases 1 and 2, respectively. Tables K.4-3 and K.4-4 provide the life-cycle costs for Alternative 2A, Cases 1 and 2, respectively.

K.4.1.3 Alternative 2C Cost Summaries and Life-Cycle Costs

Figure K.4-5 provides the cost summary for Alternative 2C, Case 2. Table K.4-5 provides the life-cycle costs for Alternative 2C, Case 2. The Cost Summary and life-cycle costs for Alternative 2C, Case 1, are identical to Alternative 1, Case 1.

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 1
LOCATION: FEMP
CASE NO. 1

SHEET: 1
DATE: 04-Nov-9
ESTD. BY: EST. DEP
CHKD. BY: F. FLOY
EST. FILE: ALT1C
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	520,228,800	0	2,529,900	522,758,700	372,783,70
2	OFF-SITE DISPOSAL	60,525,700	5,269,967,500	36,341,700	5,366,834,900	3,659,048,20
3	BACKFILL	57,411,300	0	0	57,411,300	39,893,80
4	GMA EXTRACTION (7500 GPM)	12,015,300	89,845,700	1,950,400	103,811,400	45,707,30
5	GRND. WTR. & WASTE WTR. TREATMENT (7500 GPM)	52,345,500	888,385,200	26,870,100	967,610,800	402,921,40
6	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,70
7	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,00
8	CONTAMINATION SURVEYS	1,556,500	536,483,500	0	540,042,000	367,802,00
TOTAL COSTS (ALTERNATIVE 1 - 1)		710,286,100	6,883,524,800	70,661,200	7,664,472,100	4,962,900,10
TOTAL ESCALATED COST					17,102,566,700	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-1 - ALTERNATIVE 1, CASE 1, COST SUMMARY

001069

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 1
LOCATION: FEMP
CASE NO. 2

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT1C2
REV. #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	147,712,600	0	718,300	148,430,900	105,847,400
2	OFF-SITE DISPOSAL	15,536,000	1,352,718,900	8,328,300	1,377,583,200	939,220,900
3	BACKFILL	29,203,700	0	0	29,203,700	20,684,600
4	GMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,700
5	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,987,000	25,715,000	392,859,700	253,879,300
6	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
7	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
8	CONTAMINATION SURVEYS	1,558,500	121,184,500	0	122,743,000	83,885,000
TOTAL COSTS (ALTERNATIVE 1 - 2)		257,994,200	1,918,469,100	40,573,700	2,217,057,000	1,506,124,600
TOTAL ESCALATED COST					3,906,391,300	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-2 - ALTERNATIVE 1, CASE 2, COST SUMMARY

TABLE K.4-1

ALTRNATIVE 1, CASE 1, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		5,025,800		5,025,800
1996	7,087,300	5,025,800		12,113,100
1997	214,183,900	171,326,700		385,510,600
1998	44,455,900	271,744,200		316,200,100
1999		271,744,200		271,744,200
2000	44,455,900	271,744,200		316,200,100
2001		271,744,200		271,744,200
2002	44,455,900	271,744,200		316,200,100
2003		271,744,200		271,744,200
2004	44,455,900	271,744,200		316,200,100
2005		271,744,200		271,744,200
2006	44,455,900	271,744,200		316,200,100
2007		271,744,200		271,744,200
2008	44,455,900	271,744,200		316,200,100
2009		271,744,200		271,744,200
2010	44,455,900	271,744,200		316,200,100
2011		271,744,200		271,744,200
2012	44,455,900	271,744,200		316,200,100
2013		271,744,200		271,744,200
2014	44,455,900	271,744,200		316,200,100
2015		271,744,200		271,744,200
2016	44,455,900	271,744,200		316,200,100
2017		271,744,200		271,744,200
2018	44,455,900	271,744,200		316,200,100
2019		271,744,200		271,744,200
2020		14,770,900	41,840,700	56,611,600
2021		14,770,900		14,770,900
2022		14,770,900		14,770,900
2023		14,770,900		14,770,900
2024		14,770,900		14,770,900
2025		14,770,900		14,770,900
2026		14,770,900		14,770,900
2027		14,770,900		14,770,900
2028		14,770,900		14,770,900
2029		14,770,900		14,770,900
2030		14,770,900		14,770,900
2031		14,770,900		14,770,900
2032		14,770,900		14,770,900
2033		14,770,900		14,770,900
2034		14,770,900		14,770,900
2035		14,770,900		14,770,900
2036		14,770,900		14,770,900
2037		14,770,900		14,770,900
2038		14,770,900		14,770,900
2039		14,770,900		14,770,900
2040		14,770,900		14,770,900
2041		14,770,900		14,770,900
2042		14,770,900		14,770,900
2043		14,770,900		14,770,900
2044		14,770,900		14,770,900
2045		14,770,900		14,770,900
2046		14,770,900		14,770,900
2047		14,770,900		14,770,900
2048		14,770,900		14,770,900
2049		14,770,900		14,770,900
2050		14,770,900		14,770,900
2051		14,770,900		14,770,900
2052		14,770,900		14,770,900
2053		14,770,900		14,770,900
2054		14,770,900		14,770,900
2055		14,770,900		14,770,900
2056		14,770,900		14,770,900
2057		14,770,900		14,770,900
2058		14,770,900		14,770,900
2059		14,770,900		14,770,900
2060		14,770,900		14,770,900
2061		14,770,900		14,770,900
2062		14,770,900		14,770,900
2063		14,770,900		14,770,900
2064		14,770,900		14,770,900

001071

TABLE K.4-1 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065		14,770,900		14,770,900
2066		14,770,900		14,770,900
2067		14,770,900		14,770,900
2068		14,770,900		14,770,900
2069			28,820,500	28,820,500
TOTALS	$710,286,100	$6,883,524,800	$70,661,200	$7,664,472,100

001072

TABLE K.4-2

ALTERNATIVE 1, CASE 2, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLARS)
1994				
1995		2603400		2,603,400
1996	2,564,300	2603400		5,167,700
1997	57,991,400	4104500		62,095,900
1998	30,686,900	83,671,400		114,358,300
1999	15,568,600	83,671,400		99,240,000
2000	15,118,300	83,671,400		98,789,700
2001		83,671,400		83,671,400
2002	15,118,300	83,671,400		98,789,700
2003		83,671,400		83,671,400
2004	15,118,300	83,671,400		98,789,700
2005		83,671,400		83,671,400
2006	15,118,300	83,671,400		98,789,700
2007		83,671,400		83,671,400
2008	15,118,300	83,671,400		98,789,700
2009		83,671,400		83,671,400
2010	15,118,300	83,671,400		98,789,700
2011		83,671,400		83,671,400
2012	15,118,300	83,671,400		98,789,700
2013		83,671,400		83,671,400
2014	15,118,300	83,671,400		98,789,700
2015		83,671,400		83,671,400
2016	15,118,300	83,671,400		98,789,700
2017		83,671,400		83,671,400
2018	15,118,300	83,671,400		98,789,700
2019		83,671,400		83,671,400
2020		13,681,400	13,015,700	26,697,100
2021		13,681,400		13,681,400
2022		13,681,400		13,681,400
2023		13,681,400		13,681,400
2024		13,681,400		13,681,400
2025			27,558,000	27,558,000
2026				
2027				
2028				
2029				
TOTALS	$257,994,200	$1,918,489,100	$40,573,700	$2,217,057,000

001073

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 2A
LOCATION: FEMP
CASE NO. 1

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT2AC1
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	520,226,800	0	2,529,900	522,756,700	372,783,700
2	OFF-SITE DISPOSAL	1,171,200	46,900,000	703,200	47,774,400	32,650,000
3	ON-SITE DISPOSAL CELL	1,333,939,700	0	223,545,200	1,557,484,900	982,109,800
4	BACKFILL	57,411,300	0	0	57,411,300	40,258,200
5	GMA EXTRACTION (7500 GPM)	12,015,300	89,645,700	1,950,400	103,611,400	45,707,300
6	GRND. WTR. & WASTE WTR. TREATMENT (7500 GPM)	52,345,500	888,395,200	26,870,100	967,610,800	402,921,400
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,558,500	538,483,500	0	540,042,000	367,802,000
TOTAL COSTS (ALTERNATIVE 2A - 1)		1,984,871,300	1,659,457,300	258,567,900	3,902,898,500	2,318,976,100
TOTAL ESCALATED COST					13,516,546,500	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-3 - ALTERNATIVE 2A, CASE 1, COST SUMMARY

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 2A
LOCATION: FEMP
CASE NO. 2

SHEET: 1
DATE: 04-Nov-9
ESTD. BY: EST. DEP
CHKD. BY: F. FLOY
EST. FILE: ALT2AC
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	147,712,600	0	718,300	148,430,900	105,647,40
2	OFF-SITE DISPOSAL	585,600	22,950,000	351,600	23,887,200	16,325,00
3	ON-SITE DISPOSAL CELL	339,939,500	0	56,968,000	396,907,500	250,279,80
4	BACKFILL	29,203,700	0	0	29,203,700	20,684,80
5	OMA EXTRACTION (6300 GPM)	10,804,700	27,585,800	1,643,000	40,033,500	27,863,70
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,987,000	25,715,000	392,869,700	253,879,30
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,70
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,00
9	CONTAMINATION SURVEYS	1,556,500	121,184,500	0	122,743,000	83,885,00
TOTAL COSTS (ALTERNATIVE 2A - 2)		582,983,300	588,720,200	88,585,000	1,260,288,500	833,508,30
TOTAL ESCALATED COST					3,021,675,600	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-4 - ALTERNATIVE 2A, CASE 2, COST SUMMARY

001075

TABLE K.4-3

ALTERNATIVE 2A, CASE 1, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLARS)
1994				
1995		5,085,900		5,085,900
1996	21,234,600	5,085,900		26,320,500
1997	132,740,200	6,586,100		139,326,300
1998	183,822,500	34,286,700		218,109,200
1999	21,239,000	34,286,700		55,525,700
2000	162,583,500	72,548,300		235,131,800
2001		72,548,300		72,548,300
2002	162,583,500	72,548,300		235,131,800
2003		72,548,300		72,548,300
2004	162,583,500	72,548,300		235,131,800
2005		72,548,300		72,548,300
2006	162,583,500	72,548,300		235,131,800
2007		72,548,300		72,548,300
2008	162,583,500	72,548,300		235,131,800
2009		72,548,300		72,548,300
2010	162,583,500	72,548,300		235,131,800
2011		72,548,300		72,548,300
2012	162,583,500	72,548,300		235,131,800
2013		72,548,300		72,548,300
2014	162,583,500	72,548,300		235,131,800
2015		72,548,300		72,548,300
2016	162,583,500	72,548,300		235,131,800
2017		72,548,300		72,548,300
2018	162,583,500	72,548,300		235,131,800
2019		72,548,300		72,548,300
2020		2,463,200	5,491,100	7,954,300
2021		2,463,200	2,258,000	4,721,200
2022		2,463,200	2,258,000	4,721,200
2023		2,463,200	2,258,000	4,721,200
2024		2,463,200	2,258,000	4,721,200
2025		2,463,200	2,258,000	4,721,200
2026		2,463,200	2,258,000	4,721,200
2027		2,463,200	2,258,000	4,721,200
2028		2,463,200	2,258,000	4,721,200
2029		2,463,200	2,258,000	4,721,200
2030		2,463,200	2,258,000	4,721,200
2031		2,463,200	2,258,000	4,721,200
2032		2,463,200	2,258,000	4,721,200
2033		2,463,200	2,258,000	4,721,200
2034		2,463,200	2,258,000	4,721,200
2035		2,463,200	2,258,000	4,721,200
2036		2,463,200	2,258,000	4,721,200
2037		2,463,200	2,258,000	4,721,200
2038		2,463,200	2,258,000	4,721,200
2039		2,463,200	2,258,000	4,721,200
2040		2,463,200	2,258,000	4,721,200
2041		2,463,200	2,258,000	4,721,200
2042		2,463,200	2,258,000	4,721,200
2043		2,463,200	2,258,000	4,721,200
2044		2,463,200	2,258,000	4,721,200
2045		2,463,200	2,258,000	4,721,200
2046		2,463,200	2,258,000	4,721,200
2047		2,463,200	2,258,000	4,721,200
2048		2,463,200	2,258,000	4,721,200
2049		2,463,200	2,258,000	4,721,200
2050		2,463,200	2,258,000	4,721,200
2051		2,463,200	2,258,000	4,721,200
2052		2,463,200	2,258,000	4,721,200
2053		2,463,200	2,258,000	4,721,200
2054		2,463,200	2,258,000	4,721,200
2055		2,463,200	2,258,000	4,721,200
2056		2,463,200	2,258,000	4,721,200
2057		2,463,200	2,258,000	4,721,200
2058		2,463,200	2,258,000	4,721,200
2059		2,463,200	2,258,000	4,721,200
2060		2,463,200	2,258,000	4,721,200
2061		2,463,200	2,258,000	4,721,200
2062		2,463,200	2,258,000	4,721,200
2063		2,463,200	2,258,000	4,721,200
2064		2,463,200	2,258,000	4,721,200

TABLE K.4-3 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLARS)
2065		2,463,200	2,258,000	4,721,200
2066		2,463,200	2,258,000	4,721,200
2067		2,463,200	2,258,000	4,721,200
2068		2,463,200	2,258,000	4,721,200
2069		2,463,200	2,258,000	4,721,200
2070			34,050,800	34,050,800
2071			2,258,000	2,258,000
2072			2,258,000	2,258,000
2073			2,258,000	2,258,000
2074			2,258,000	2,258,000
2075			2,258,000	2,258,000
2076			2,258,000	2,258,000
2077			2,258,000	2,258,000
2078			2,258,000	2,258,000
2079			2,258,000	2,258,000
2080			2,258,000	2,258,000
2081			2,258,000	2,258,000
2082			2,258,000	2,258,000
2083			2,258,000	2,258,000
2084			2,258,000	2,258,000
2085			2,258,000	2,258,000
2086			2,258,000	2,258,000
2087			2,258,000	2,258,000
2088			2,258,000	2,258,000
2089			2,258,000	2,258,000
2090			2,258,000	2,258,000
2091			2,258,000	2,258,000
2092			2,258,000	2,258,000
2093			2,258,000	2,258,000
2094			2,258,000	2,258,000
2095			2,258,000	2,258,000
2096			2,258,000	2,258,000
2097			2,258,000	2,258,000
2098			2,258,000	2,258,000
2099			2,258,000	2,258,000
2100			2,258,000	2,258,000
2101			2,258,000	2,258,000
2102			2,258,000	2,258,000
2103			2,258,000	2,258,000
2104			2,258,000	2,258,000
2105			2,258,000	2,258,000
2106			2,258,000	2,258,000
2107			2,258,000	2,258,000
2108			2,258,000	2,258,000
2109			2,258,000	2,258,000
2110			2,258,000	2,258,000
2111			2,258,000	2,258,000
2112			2,258,000	2,258,000
2113			2,258,000	2,258,000
2114			2,258,000	2,258,000
2115			2,258,000	2,258,000
2116			2,258,000	2,258,000
2117			2,258,000	2,258,000
2118			2,258,000	2,258,000
TOTALS	$1,984,871,300	$1,659,457,300	$258,567,900	$3,902,896,500

001077

6349

TABLE K.4-4

ALTERNATIVE 2A, CASE 2, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	2,414,800	2,437,900		4,852,700
1997	74,327,600	3,936,900		78,264,500
1998	46,021,900	10,489,500		56,511,400
1999		10,489,500		10,489,500
2000	46,021,900	24,517,800		70,539,700
2001		24,517,800		24,517,800
2002	46,021,900	24,517,800		70,539,700
2003		24,517,800		24,517,800
2004	46,021,900	24,517,800		70,539,700
2005		24,517,800		24,517,800
2006	46,021,900	24,517,800		70,539,700
2007		24,517,800		24,517,800
2008	46,021,900	24,517,800		70,539,700
2009		24,517,800		24,517,800
2010	46,021,900	24,517,800		70,539,700
2011		24,517,800		24,517,800
2012	46,021,900	24,517,800		70,539,700
2013		24,517,800		24,517,800
2014	46,021,900	24,517,800		70,539,700
2015		24,517,800		24,517,800
2016	46,021,900	24,517,800		70,539,700
2017		24,517,800		24,517,800
2018	46,021,900	24,517,800		70,539,700
2019		24,517,800		24,517,800
2020		13,714,500	4,627,600	18,342,100
2021		13,714,500	575,300	14,289,800
2022		13,714,500	575,300	14,289,800
2023		13,714,500	575,300	14,289,800
2024		13,714,500	575,300	14,289,800
2025			28,133,300	28,133,300
2026			575,300	575,300
2027			575,300	575,300
2028			575,300	575,300
2029			575,300	575,300
2030			575,300	575,300
2031			575,300	575,300
2032			575,300	575,300
2033			575,300	575,300
2034			575,300	575,300
2035			575,300	575,300
2036			575,300	575,300
2037			575,300	575,300
2038			575,300	575,300
2039			575,300	575,300
2040			575,300	575,300
2041			575,300	575,300
2042			575,300	575,300
2043			575,300	575,300
2044			575,300	575,300
2045			575,300	575,300
2046			575,300	575,300
2047			575,300	575,300
2048			575,300	575,300
2049			575,300	575,300
2050			575,300	575,300
2051			575,300	575,300
2052			575,300	575,300
2053			575,300	575,300
2054			575,300	575,300
2055			575,300	575,300
2056			575,300	575,300
2057			575,300	575,300
2058			575,300	575,300
2059			575,300	575,300
2060			575,300	575,300
2061			575,300	575,300
2062			575,300	575,300
2063			575,300	575,300
2064			575,300	575,300

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TABLE K.4-4 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT DOLLAR)
2065			575,300	575,300
2066			575,300	575,300
2067			575,300	575,300
2068			575,300	575,300
2069			575,300	575,300
2070			575,300	575,300
2071			575,300	575,300
2072			575,300	575,300
2073			575,300	575,300
2074			575,300	575,300
2075			575,300	575,300
2076			575,300	575,300
2077			575,300	575,300
2078			575,300	575,300
2079			575,300	575,300
2080			575,300	575,300
2081			575,300	575,300
2082			575,300	575,300
2083			575,300	575,300
2084			575,300	575,300
2085			575,300	575,300
2086			575,300	575,300
2087			575,300	575,300
2088			575,300	575,300
2089			575,300	575,300
2090			575,300	575,300
2091			575,300	575,300
2092			575,300	575,300
2093			575,300	575,300
2094			575,300	575,300
2095			575,300	575,300
2096			575,300	575,300
2097			575,300	575,300
2098			575,300	575,300
2099			575,300	575,300
2100			575,300	575,300
2101			575,300	575,300
2102			575,300	575,300
2103			575,300	575,300
2104			575,300	575,300
2105			575,300	575,300
2106			575,300	575,300
2107			575,300	575,300
2108			575,300	575,300
2109			575,300	575,300
2110			575,300	575,300
2111			575,300	575,300
2112			575,300	575,300
2113			575,300	575,300
2114			575,300	575,300
2115			575,300	575,300
2116			575,300	575,300
2117			575,300	575,300
2118			575,300	575,300
TOTALS	$582,983,300	$588,720,200	$88,565,000	$1,260,268,500

001079

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 2C
LOCATION: FEMP
CASE NO. 2

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT2CC2
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	147,712,600	0	718,300	148,430,900	105,847,400
2	OFF-SITE DISPOSAL	9,975,400	659,993,200	5,969,600	675,958,200	461,042,400
3	CONSOLIDATION AND COVER	94,069,200	0	38,521,300	132,590,500	73,658,400
4	BACKFILL	29,203,700	0	0	29,203,700	20,287,000
5	OMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,700
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,967,000	25,715,000	392,859,700	253,879,300
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,558,500	121,184,500	0	122,743,000	83,885,000
TOTAL COSTS (ALTERNATIVE 2C - 2)		346,502,800	1,225,763,400	75,756,300	1,648,022,500	1,101,186,900
TOTAL ESCALATED COST					3,430,442,700	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-5 - ALTERNATIVE 2C, CASE 2, COST SUMMARY

TABLE K.4-5
ALTERNATIVE 2C, CASE 2, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	3,449,400	2,437,900		5,887,300
1997	88,326,400	3,939,300		92,265,700
1998	23,157,000	52,198,900		75,355,900
1999		52,198,900		52,198,900
2000	23,157,000	52,198,900		75,355,900
2001		52,198,900		52,198,900
2002	23,157,000	52,198,900		75,355,900
2003		52,198,900		52,198,900
2004	23,157,000	52,198,900		75,355,900
2005		52,198,900		52,198,900
2006	23,157,000	52,198,900		75,355,900
2007		52,198,900		52,198,900
2008	23,157,000	52,198,900		75,355,900
2009		52,198,900		52,198,900
2010	23,157,000	52,198,900		75,355,900
2011		52,198,900		52,198,900
2012	23,157,000	52,198,900		75,355,900
2013		52,198,900		52,198,900
2014	23,157,000	52,198,900		75,355,900
2015		52,198,900		52,198,900
2016	23,157,000	52,198,900		75,355,900
2017		52,198,900		52,198,900
2018	23,157,000	52,198,900		75,355,900
2019		52,198,900		52,198,900
2020		13,714,500	10,066,100	23,780,600
2021		13,714,500	389,100	14,103,600
2022		13,714,500	389,100	14,103,600
2023		13,714,500	389,100	14,103,600
2024		13,714,500	389,100	14,103,600
2025			27,947,500	27,947,500
2026			389,100	389,100
2027			389,100	389,100
2028			389,100	389,100
2029			389,100	389,100
2030			389,100	389,100
2031			389,100	389,100
2032			389,100	389,100
2033			389,100	389,100
2034			389,100	389,100
2035			389,100	389,100
2036			389,100	389,100
2037			389,100	389,100
2038			389,100	389,100
2039			389,100	389,100
2040			389,100	389,100
2041			389,100	389,100
2042			389,100	389,100
2043			389,100	389,100
2044			389,100	389,100
2045			389,100	389,100
2046			389,100	389,100
2047			389,100	389,100
2048			389,100	389,100
2049			389,100	389,100
2050			389,100	389,100
2051			389,100	389,100
2052			389,100	389,100
2053			389,100	389,100
2054			389,100	389,100
2055			389,100	389,100
2056			389,100	389,100
2057			389,100	389,100
2058			389,100	389,100
2059			389,100	389,100
2060			389,100	389,100
2061			389,100	389,100
2062			389,100	389,100
2063			389,100	389,100
2064			389,100	389,100

001081

TABLE K.4-5 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			389,100	389,100
2066			389,100	389,100
2067			389,100	389,100
2068			389,100	389,100
2069			389,100	389,100
2070			389,100	389,100
2071			389,100	389,100
2072			389,100	389,100
2073			389,100	389,100
2074			389,100	389,100
2075			389,100	389,100
2076			389,100	389,100
2077			389,100	389,100
2078			389,100	389,100
2079			389,100	389,100
2080			389,100	389,100
2081			389,100	389,100
2082			389,100	389,100
2083			389,100	389,100
2084			389,100	389,100
2085			389,100	389,100
2086			389,100	389,100
2087			389,100	389,100
2088			389,100	389,100
2089			389,100	389,100
2090			389,100	389,100
2091			389,100	389,100
2092			389,100	389,100
2093			389,100	389,100
2094			389,100	389,100
2095			389,100	389,100
2096			389,100	389,100
2097			389,100	389,100
2098			389,100	389,100
2099			389,100	389,100
2100			389,100	389,100
2101			389,100	389,100
2102			389,100	389,100
2103			389,100	389,100
2104			389,100	389,100
2105			389,100	389,100
2106			389,100	389,100
2107			389,100	389,100
2108			389,100	389,100
2109			389,100	389,100
2110			389,100	389,100
2111			389,100	389,100
2112			389,100	389,100
2113			389,100	389,100
2114			389,100	389,100
2115			389,100	389,100
2116			389,100	389,100
2117			389,100	389,100
2118			389,100	389,100
TOTALS	$346,502,800	$1,225,763,400	$75,756,300	$1,648,022,500

K.4.1.4 Alternative 3A Cost Summaries and Life-Cycle Costs

Figures K.4-6, K.4-7, K.4-8, K.4-9 and K.4-10 provide the cost summaries for Alternative 3A, Cases 3 through 7, respectively. Tables K.4-6, K.4-7, K.4-8, K.4-9 and K.4-10 provide the life-cycle costs for Alternative 3A, Cases 3 through 7, respectively.

K.4.1.5 Alternative 3C Cost Summaries and Life-Cycle Costs

Figures K.4-11, K.4-12, K.4-13, K.4-14 and K.4-15 provide the cost summaries for Alternative 3C, Cases 3 through 7, respectively. Tables K.4-11, K.4-12, K.4-13, K.4-14 and K.4-15 provide the life-cycle costs for Alternative 3C, Cases 3 through 7, respectively.

K.4.1.6 Alternative 4A Cost Summaries and Life-Cycle Costs

Figures K.4-16 and K.4-17 provide the cost summaries for Alternative 4A, Cases 8 and 9, respectively. Tables K.4-16 and K.4-17 provide the life-cycle costs for Alternative 4A, Cases 8 and 9, respectively.

K.4.1.7 Alternative 4C Cost Summaries and Life-Cycle Costs

Figures K.4-18 and K.4-19 provide the cost summaries for Alternative 4C, Cases 8 and 9, respectively. Tables K.4-18 and K.4-19 provide the life-cycle costs for Alternative 4C, Cases 8 and 9, respectively.

001083

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3A
LOCATION: FEMP
CASE NO. 3

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT3AC3
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	128,844,200	0	626,600	129,470,800	92,326,700
2	OFF-SITE DISPOSAL	586,600	22,950,000	351,600	23,887,200	16,325,000
3	ON-SITE DISPOSAL CELL	335,636,400	0	56,246,900	391,883,300	247,111,500
4	BACKFILL	19,695,900	0	0	19,695,900	13,687,400
5	OMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,700
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,967,000	25,715,000	392,859,700	253,879,300
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,556,500	108,869,500	0	110,426,000	75,506,000
TOTAL COSTS (ALTERNATIVE 3A - 3)		550,304,000	576,405,200	87,752,200	1,214,461,400	801,453,300
TOTAL ESCALATED COST					2,946,230,600	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-6 - ALTERNATIVE 3A, CASE 3, COST SUMMARY

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3A
LOCATION: FEMP
CASE NO. 4

SHEET: 1
DATE: 04-Nov-9
ESTD. BY: EST. DEP
CHKD. BY: F. FLOY
EST. FILE: ALT3AC
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	116,601,400	0	576,800	119,178,200	84,986,90
2	OFF-SITE DISPOSAL	565,600	22,950,000	351,600	23,867,200	16,325,00
3	ON-SITE DISPOSAL CELL	271,862,900	0	46,937,100	318,820,000	200,564,00
4	BACKFILL	20,338,700	0	0	20,338,700	14,090,60
5	OMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,70
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,967,000	25,715,000	392,859,700	253,879,30
7	CENTRAL STORAGE FACITIY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,70
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,00
9	CONTAMINATION SURVEYS	1,558,500	98,585,500	0	100,144,000	68,509,00
TOTAL COSTS (ALTERNATIVE 3A - 4)		476,950,500	566,121,200	78,392,800	1,121,464,300	740,962,20
TOTAL ESCALATED COST					2,664,052,700	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-7 - ALTERNATIVE 3A, CASE 4, COST SUMMARY

001085

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3A
LOCATION: FEMP
CASE NO. 5

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT3AC5
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	116,062,300	0	574,100	116,636,400	84,600,600
2	OFF-SITE DISPOSAL	585,600	22,950,000	351,600	23,887,200	16,325,000
3	ON-SITE DISPOSAL CELL	271,882,900	0	46,937,100	318,820,000	200,564,000
4	BACKFILL	20,338,700	0	0	20,338,700	14,090,600
5	GMA EXTRACTION (6300 GPM)	10,804,700	27,585,800	1,643,000	40,033,500	27,863,700
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,987,000	25,715,000	392,859,700	253,879,300
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,556,500	72,670,500	0	74,229,000	50,877,000
TOTAL COSTS (ALTERNATIVE 3A - 5)		476,411,400	540,206,200	78,389,900	1,095,007,500	722,943,900
TOTAL ESCALATED COST					2,618,096,300	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-8 - ALTERNATIVE 3A, CASE 5, COST SUMMARY

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3A
LOCATION: FEMP
CASE NO. 6

SHEET: 1
DATE: 04-Nov-
ESTD. BY: EST. DE
CHKD. BY: F. FLO
EST. FILE: ALT3A
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	103,189,200	0	524,200	103,713,400	73,388,9
2	OFF-SITE DISPOSAL	565,600	22,950,000	351,600	23,887,200	16,325,0
3	ON-SITE DISPOSAL CELL	271,882,900	0	46,937,100	318,820,000	200,564,0
4	BACKFILL	21,535,800	0	0	21,535,800	14,977,3
5	OMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,7
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	318,967,000	26,715,000	392,859,700	253,879,3
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,7
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,0
9	CONTAMINATION SURVEYS	1,568,500	45,012,500	0	46,571,000	32,060,0
TOTAL COSTS (ALTERNATIVE 3A - 6)		462,735,400	512,548,200	78,340,000	1,053,623,800	693,802,9
TOTAL ESCALATED COST					2,548,748,500	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-9 - ALTERNATIVE 3A, CASE 6, COST SUMMARY

001087

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3A
LOCATION: FEMP
CASE NO. 7

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT3AC7
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	103,409,700	0	524,200	103,933,900	73,574,200
2	OFF-SITE DISPOSAL	565,600	22,950,000	351,600	23,867,200	16,325,000
3	ON-SITE DISPOSAL CELL	271,882,900	0	46,937,100	318,820,000	200,564,000
4	BACKFILL	21,044,600	0	0	21,044,600	14,635,600
5	OMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,700
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,967,000	25,715,000	392,859,700	253,879,300
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,556,500	45,402,500	0	46,961,000	32,325,000
TOTAL COSTS (ALTERNATIVE 3A - 7)		462,464,700	512,938,200	78,340,000	1,053,742,800	693,910,500
TOTAL ESCALATED COST					2,546,869,900	

FIGURE K.4-10 - ALTERNATIVE 3A, CASE 7, COST SUMMARY

TABLE K.4-6

ALTERNATIVE 3A, CASE 3, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	5,487,500	2,437,900		7,925,400
1997	89,690,400	3,937,500		93,627,900
1998	41,375,100	9,929,700		51,304,800
1999		9,929,700		9,929,700
2000	41,375,100	23,958,000		65,333,100
2001		23,958,000		23,958,000
2002	41,375,100	23,958,000		65,333,100
2003		23,958,000		23,958,000
2004	41,375,100	23,958,000		65,333,100
2005		23,958,000		23,958,000
2006	41,375,100	23,958,000		65,333,100
2007		23,958,000		23,958,000
2008	41,375,100	23,958,000		65,333,100
2009		23,958,000		23,958,000
2010	41,375,100	23,958,000		65,333,100
2011		23,958,000		23,958,000
2012	41,375,100	23,958,000		65,333,100
2013		23,958,000		23,958,000
2014	41,375,100	23,958,000		65,333,100
2015		23,958,000		23,958,000
2016	41,375,100	23,958,000		65,333,100
2017		23,958,000		23,958,000
2018	41,375,100	23,958,000		65,333,100
2019		23,958,000		23,958,000
2020		13,714,500	4,510,600	18,225,100
2021		13,714,500	568,200	14,282,700
2022		13,714,500	568,200	14,282,700
2023		13,714,500	568,200	14,282,700
2024		13,714,500	568,200	14,282,700
2025			28,126,200	28,126,200
2026			568,200	568,200
2027			568,200	568,200
2028			568,200	568,200
2029			568,200	568,200
2030			568,200	568,200
2031			568,200	568,200
2032			568,200	568,200
2033			568,200	568,200
2034			568,200	568,200
2035			568,200	568,200
2036			568,200	568,200
2037			568,200	568,200
2038			568,200	568,200
2039			568,200	568,200
2040			568,200	568,200
2041			568,200	568,200
2042			568,200	568,200
2043			568,200	568,200
2044			568,200	568,200
2045			568,200	568,200
2046			568,200	568,200
2047			568,200	568,200
2048			568,200	568,200
2049			568,200	568,200
2050			568,200	568,200
2051			568,200	568,200
2052			568,200	568,200
2053			568,200	568,200
2054			568,200	568,200
2055			568,200	568,200
2056			568,200	568,200
2057			568,200	568,200
2058			568,200	568,200
2059			568,200	568,200
2060			568,200	568,200
2061			568,200	568,200
2062			568,200	568,200
2063			568,200	568,200
2064			568,200	568,200

001089

TABLE K.4-6 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			568,200	568,200
2066			568,200	568,200
2067			568,200	568,200
2068			568,200	568,200
2069			568,200	568,200
2070			568,200	568,200
2071			568,200	568,200
2072			568,200	568,200
2073			568,200	568,200
2074			568,200	568,200
2075			568,200	568,200
2076			568,200	568,200
2077			568,200	568,200
2078			568,200	568,200
2079			568,200	568,200
2080			568,200	568,200
2081			568,200	568,200
2082			568,200	568,200
2083			568,200	568,200
2084			568,200	568,200
2085			568,200	568,200
2086			568,200	568,200
2087			568,200	568,200
2088			568,200	568,200
2089			568,200	568,200
2090			568,200	568,200
2091			568,200	568,200
2092			568,200	568,200
2093			568,200	568,200
2094			568,200	568,200
2095			568,200	568,200
2096			568,200	568,200
2097			568,200	568,200
2098			568,200	568,200
2099			568,200	568,200
2100			568,200	568,200
2101			568,200	568,200
2102			568,200	568,200
2103			568,200	568,200
2104			568,200	568,200
2105			568,200	568,200
2106			568,200	568,200
2107			568,200	568,200
2108			568,200	568,200
2109			568,200	568,200
2110			568,200	568,200
2111			568,200	568,200
2112			568,200	568,200
2113			568,200	568,200
2114			568,200	568,200
2115			568,200	568,200
2116			568,200	568,200
2117			568,200	568,200
2118			568,200	568,200
TOTALS	$550,304,000	$576,405,200	$87,752,200	$1,214,461,400

TABLE K.4-7
ALTERNATIVE 3A, CASE 4, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	4,753,900	2,437,900		7,191,800
1997	86,024,000	3,938,500		89,962,500
1998	35,106,600	9,462,200		44,568,800
1999		9,462,200		9,462,200
2000	35,106,600	23,490,500		58,597,100
2001		23,490,500		23,490,500
2002	35,106,600	23,490,500		58,597,100
2003		23,490,500		23,490,500
2004	35,106,600	23,490,500		58,597,100
2005		23,490,500		23,490,500
2006	35,106,600	23,490,500		58,597,100
2007		23,490,500		23,490,500
2008	35,106,600	23,490,500		58,597,100
2009		23,490,500		23,490,500
2010	35,106,600	23,490,500		58,597,100
2011		23,490,500		23,490,500
2012	35,106,600	23,490,500		58,597,100
2013		23,490,500		23,490,500
2014	35,106,600	23,490,500		58,597,100
2015		23,490,500		23,490,500
2016	35,106,600	23,490,500		58,597,100
2017		23,490,500		23,490,500
2018	35,106,600	23,490,500		58,597,100
2019		23,490,500		23,490,500
2020		13,714,500	4,401,900	18,116,400
2021		13,714,500	478,700	14,193,200
2022		13,714,500	478,700	14,193,200
2023		13,714,500	478,700	14,193,200
2024		13,714,500	478,700	14,193,200
2025			27,556,800	27,556,800
2026			478,700	478,700
2027			478,700	478,700
2028			478,700	478,700
2029			478,700	478,700
2030			478,700	478,700
2031			478,700	478,700
2032			478,700	478,700
2033			478,700	478,700
2034			478,700	478,700
2035			478,700	478,700
2036			478,700	478,700
2037			478,700	478,700
2038			478,700	478,700
2039			478,700	478,700
2040			478,700	478,700
2041			478,700	478,700
2042			478,700	478,700
2043			478,700	478,700
2044			478,700	478,700
2045			478,700	478,700
2046			478,700	478,700
2047			478,700	478,700
2048			478,700	478,700
2049			478,700	478,700
2050			478,700	478,700
2051			478,700	478,700
2052			478,700	478,700
2053			478,700	478,700
2054			478,700	478,700
2055			478,700	478,700
2056			478,700	478,700
2057			478,700	478,700
2058			478,700	478,700
2059			478,700	478,700
2060			478,700	478,700
2061			478,700	478,700
2062			478,700	478,700
2063			478,700	478,700
2064			478,700	478,700

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TABLE K.4-7 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			478,700	478,700
2066			478,700	478,700
2067			478,700	478,700
2068			478,700	478,700
2069			478,700	478,700
2070			478,700	478,700
2071			478,700	478,700
2072			478,700	478,700
2073			478,700	478,700
2074			478,700	478,700
2075			478,700	478,700
2076			478,700	478,700
2077			478,700	478,700
2078			478,700	478,700
2079			478,700	478,700
2080			478,700	478,700
2081			478,700	478,700
2082			478,700	478,700
2083			478,700	478,700
2084			478,700	478,700
2085			478,700	478,700
2086			478,700	478,700
2087			478,700	478,700
2088			478,700	478,700
2089			478,700	478,700
2090			478,700	478,700
2091			478,700	478,700
2092			478,700	478,700
2093			478,700	478,700
2094			478,700	478,700
2095			478,700	478,700
2096			478,700	478,700
2097			478,700	478,700
2098			478,700	478,700
2099			478,700	478,700
2100			478,700	478,700
2101			478,700	478,700
2102			478,700	478,700
2103			478,700	478,700
2104			478,700	478,700
2105			478,700	478,700
2106			478,700	478,700
2107			478,700	478,700
2108			478,700	478,700
2109			478,700	478,700
2110			478,700	478,700
2111			478,700	478,700
2112			478,700	478,700
2113			478,700	478,700
2114			478,700	478,700
2115			478,700	478,700
2116			478,700	478,700
2117			478,700	478,700
2118			478,700	478,700
TOTALS	$476,950,500	$566,121,200	$78,392,600	$1,121,464,300

TABLE K.4-8
ALTERNATIVE 3A, CASE 5, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	4,748,500	2,437,900		7,186,400
1997	85,996,300	3,937,300		89,933,600
1998	35,060,600	8,284,300		43,344,900
1999		8,284,300		8,284,300
2000	35,060,600	22,312,600		57,373,200
2001		22,312,600		22,312,600
2002	35,060,600	22,312,600		57,373,200
2003		22,312,600		22,312,600
2004	35,060,600	22,312,600		57,373,200
2005		22,312,600		22,312,600
2006	35,060,600	22,312,600		57,373,200
2007		22,312,600		22,312,600
2008	35,060,600	22,312,600		57,373,200
2009		22,312,600		22,312,600
2010	35,060,600	22,312,600		57,373,200
2011		22,312,600		22,312,600
2012	35,060,600	22,312,600		57,373,200
2013		22,312,600		22,312,600
2014	35,060,600	22,312,600		57,373,200
2015		22,312,600		22,312,600
2016	35,060,600	22,312,600		57,373,200
2017		22,312,600		22,312,600
2018	35,060,600	22,312,600		57,373,200
2019		22,312,600		22,312,600
2020		13,714,500	4,370,100	18,084,600
2021		13,714,500	474,100	14,188,600
2022		13,714,500	474,100	14,188,600
2023		13,714,500	474,100	14,188,600
2024		13,714,500	474,100	14,188,600
2025			28,032,100	28,032,100
2026			474,100	474,100
2027			474,100	474,100
2028			474,100	474,100
2029			474,100	474,100
2030			474,100	474,100
2031			474,100	474,100
2032			474,100	474,100
2033			474,100	474,100
2034			474,100	474,100
2035			474,100	474,100
2036			474,100	474,100
2037			474,100	474,100
2038			474,100	474,100
2039			474,100	474,100
2040			474,100	474,100
2041			474,100	474,100
2042			474,100	474,100
2043			474,100	474,100
2044			474,100	474,100
2045			474,100	474,100
2046			474,100	474,100
2047			474,100	474,100
2048			474,100	474,100
2049			474,100	474,100
2050			474,100	474,100
2051			474,100	474,100
2052			474,100	474,100
2053			474,100	474,100
2054			474,100	474,100
2055			474,100	474,100
2056			474,100	474,100
2057			474,100	474,100
2058			474,100	474,100
2059			474,100	474,100
2060			474,100	474,100
2061			474,100	474,100
2062			474,100	474,100
2063			474,100	474,100

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TABLE K.4-8 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2064			474,100	474,100
2065			474,100	474,100
2066			474,100	474,100
2067			474,100	474,100
2068			474,100	474,100
2069			474,100	474,100
2070			474,100	474,100
2071			474,100	474,100
2072			474,100	474,100
2073			474,100	474,100
2074			474,100	474,100
2075			474,100	474,100
2076			474,100	474,100
2077			474,100	474,100
2078			474,100	474,100
2079			474,100	474,100
2080			474,100	474,100
2081			474,100	474,100
2082			474,100	474,100
2083			474,100	474,100
2084			474,100	474,100
2085			474,100	474,100
2086			474,100	474,100
2087			474,100	474,100
2088			474,100	474,100
2089			474,100	474,100
2090			474,100	474,100
2091			474,100	474,100
2092			474,100	474,100
2093			474,100	474,100
2094			474,100	474,100
2095			474,100	474,100
2096			474,100	474,100
2097			474,100	474,100
2098			474,100	474,100
2099			474,100	474,100
2100			474,100	474,100
2101			474,100	474,100
2102			474,100	474,100
2103			474,100	474,100
2104			474,100	474,100
2105			474,100	474,100
2106			474,100	474,100
2107			474,100	474,100
2108			474,100	474,100
2109			474,100	474,100
2110			474,100	474,100
2111			474,100	474,100
2112			474,100	474,100
2113			474,100	474,100
2114			474,100	474,100
2115			474,100	474,100
2116			474,100	474,100
2117			474,100	474,100
2118			474,100	474,100
TOTALS	$476,411,400	$540,206,200	$78,389,900	$1,095,007,500

TABLE K.4-9

ALTERNATIVE 3A, CASE 6, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	4,611,800	2,437,900		7,049,700
1997	85,312,700	3,937,700		89,250,400
1998	33,891,900	7,027,100		40,919,000
1999		7,027,100		7,027,100
2000	33,891,900	21,055,400		54,947,300
2001		21,055,400		21,055,400
2002	33,891,900	21,055,400		54,947,300
2003		21,055,400		21,055,400
2004	33,891,900	21,055,400		54,947,300
2005		21,055,400		21,055,400
2006	33,891,900	21,055,400		54,947,300
2007		21,055,400		21,055,400
2008	33,891,900	21,055,400		54,947,300
2009		21,055,400		21,055,400
2010	33,891,900	21,055,400		54,947,300
2011		21,055,400		21,055,400
2012	33,891,900	21,055,400		54,947,300
2013		21,055,400		21,055,400
2014	33,891,900	21,055,400		54,947,300
2015		21,055,400		21,055,400
2016	33,891,900	21,055,400		54,947,300
2017		21,055,400		21,055,400
2018	33,891,900	21,055,400		54,947,300
2019		21,055,400		21,055,400
2020		13,714,500	4,319,000	18,033,500
2021		13,714,500	474,100	14,188,600
2022		13,714,500	474,100	14,188,600
2023		13,714,500	474,100	14,188,600
2024		13,714,500	474,100	14,188,600
2025			28,033,300	28,033,300
2026			474,100	474,100
2027			474,100	474,100
2028			474,100	474,100
2029			474,100	474,100
2030			474,100	474,100
2031			474,100	474,100
2032			474,100	474,100
2033			474,100	474,100
2034			474,100	474,100
2035			474,100	474,100
2036			474,100	474,100
2037			474,100	474,100
2038			474,100	474,100
2039			474,100	474,100
2040			474,100	474,100
2041			474,100	474,100
2042			474,100	474,100
2043			474,100	474,100
2044			474,100	474,100
2045			474,100	474,100
2046			474,100	474,100
2047			474,100	474,100
2048			474,100	474,100
2049			474,100	474,100
2050			474,100	474,100
2051			474,100	474,100
2052			474,100	474,100
2053			474,100	474,100
2054			474,100	474,100
2055			474,100	474,100
2056			474,100	474,100
2057			474,100	474,100
2058			474,100	474,100
2059			474,100	474,100
2060			474,100	474,100
2061			474,100	474,100
2062			474,100	474,100
2063			474,100	474,100
2064			474,100	474,100

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TABLE K.4-9 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			474,100	474,100
2066			474,100	474,100
2067			474,100	474,100
2068			474,100	474,100
2069			474,100	474,100
2070			474,100	474,100
2071			474,100	474,100
2072			474,100	474,100
2073			474,100	474,100
2074			474,100	474,100
2075			474,100	474,100
2076			474,100	474,100
2077			474,100	474,100
2078			474,100	474,100
2079			474,100	474,100
2080			474,100	474,100
2081			474,100	474,100
2082			474,100	474,100
2083			474,100	474,100
2084			474,100	474,100
2085			474,100	474,100
2086			474,100	474,100
2087			474,100	474,100
2088			474,100	474,100
2089			474,100	474,100
2090			474,100	474,100
2091			474,100	474,100
2092			474,100	474,100
2093			474,100	474,100
2094			474,100	474,100
2095			474,100	474,100
2096			474,100	474,100
2097			474,100	474,100
2098			474,100	474,100
2099			474,100	474,100
2100			474,100	474,100
2101			474,100	474,100
2102			474,100	474,100
2103			474,100	474,100
2104			474,100	474,100
2105			474,100	474,100
2106			474,100	474,100
2107			474,100	474,100
2108			474,100	474,100
2109			474,100	474,100
2110			474,100	474,100
2111			474,100	474,100
2112			474,100	474,100
2113			474,100	474,100
2114			474,100	474,100
2115			474,100	474,100
2116			474,100	474,100
2117			474,100	474,100
2118			474,100	474,100
TOTALS	$462,735,400	$512,548,200	$78,340,000	$1,053,623,600

TABLE K.4-10

ALTERNATIVE 3A, CASE 7, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	4,609,000	2,437,900		7,046,900
1997	85,298,900	3,938,400		89,237,300
1998	33,868,800	7,044,800		40,913,600
1999		7,044,800		7,044,800
2000	33,868,800	21,073,100		54,941,900
2001		21,073,100		21,073,100
2002	33,868,800	21,073,100		54,941,900
2003		21,073,100		21,073,100
2004	33,868,800	21,073,100		54,941,900
2005		21,073,100		21,073,100
2006	33,868,800	21,073,100		54,941,900
2007		21,073,100		21,073,100
2008	33,868,800	21,073,100		54,941,900
2009		21,073,100		21,073,100
2010	33,868,800	21,073,100		54,941,900
2011		21,073,100		21,073,100
2012	33,868,800	21,073,100		54,941,900
2013		21,073,100		21,073,100
2014	33,868,800	21,073,100		54,941,900
2015		21,073,100		21,073,100
2016	33,868,800	21,073,100		54,941,900
2017		21,073,100		21,073,100
2018	33,868,800	21,073,100		54,941,900
2019		21,073,100		21,073,100
2020		13,714,500	4,319,000	18,033,500
2021		13,714,500	474,100	14,188,600
2022		13,714,500	474,100	14,188,600
2023		13,714,500	474,100	14,188,600
2024		13,714,500	474,100	14,188,600
2025			28,033,300	28,033,300
2026			474,100	474,100
2027			474,100	474,100
2028			474,100	474,100
2029			474,100	474,100
2030			474,100	474,100
2031			474,100	474,100
2032			474,100	474,100
2033			474,100	474,100
2034			474,100	474,100
2035			474,100	474,100
2036			474,100	474,100
2037			474,100	474,100
2038			474,100	474,100
2039			474,100	474,100
2040			474,100	474,100
2041			474,100	474,100
2042			474,100	474,100
2043			474,100	474,100
2044			474,100	474,100
2045			474,100	474,100
2046			474,100	474,100
2047			474,100	474,100
2048			474,100	474,100
2049			474,100	474,100
2050			474,100	474,100
2051			474,100	474,100
2052			474,100	474,100
2053			474,100	474,100
2054			474,100	474,100
2055			474,100	474,100
2056			474,100	474,100
2057			474,100	474,100
2058			474,100	474,100
2059			474,100	474,100
2060			474,100	474,100
2061			474,100	474,100
2062			474,100	474,100
2063			474,100	474,100
2064			474,100	474,100

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TABLE K.4-10 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			474,100	474,100
2066			474,100	474,100
2067			474,100	474,100
2068			474,100	474,100
2069			474,100	474,100
2070			474,100	474,100
2071			474,100	474,100
2072			474,100	474,100
2073			474,100	474,100
2074			474,100	474,100
2075			474,100	474,100
2076			474,100	474,100
2077			474,100	474,100
2078			474,100	474,100
2079			474,100	474,100
2080			474,100	474,100
2081			474,100	474,100
2082			474,100	474,100
2083			474,100	474,100
2084			474,100	474,100
2085			474,100	474,100
2086			474,100	474,100
2087			474,100	474,100
2088			474,100	474,100
2089			474,100	474,100
2090			474,100	474,100
2091			474,100	474,100
2092			474,100	474,100
2093			474,100	474,100
2094			474,100	474,100
2095			474,100	474,100
2096			474,100	474,100
2097			474,100	474,100
2098			474,100	474,100
2099			474,100	474,100
2100			474,100	474,100
2101			474,100	474,100
2102			474,100	474,100
2103			474,100	474,100
2104			474,100	474,100
2105			474,100	474,100
2106			474,100	474,100
2107			474,100	474,100
2108			474,100	474,100
2109			474,100	474,100
2110			474,100	474,100
2111			474,100	474,100
2112			474,100	474,100
2113			474,100	474,100
2114			474,100	474,100
2115			474,100	474,100
2116			474,100	474,100
2117			474,100	474,100
2118			474,100	474,100
TOTALS	$462,464,700	$512,938,300	$78,340,000	$1,053,743,000

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3C
LOCATION: FEMP
CASE NO. 3

SHEET: 1
DATE: 04-Nov-
ESTD. BY: EST. DE
CHKD. BY: F. FLO
EST. FILE: ALT3C
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	128,644,200	0	826,800	129,470,800	92,328,7
2	OFF-SITE DISPOSAL	9,869,400	654,303,600	5,937,900	670,130,900	467,087,9
3	CONSOLIDATION AND COVER	92,551,900	0	37,900,000	130,451,900	72,470,3
4	BACKFILL	19,695,900	0	0	19,695,900	13,697,4
5	GMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,7
6	GRND. WTR. & WASTE WTR.TREATMENT (6300 GPM)	47,177,700	319,967,000	25,715,000	392,859,700	253,879,3
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,7
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,0
9	CONTAMINATION SURVEYS	1,556,500	108,869,500	0	110,426,000	75,508,0
TOTAL COSTS (ALTERNATIVE 3C - 3)		316,523,300	1,207,758,800	74,991,600	1,599,273,700	1,087,555,0
TOTAL ESCALATED COST					3,339,469,800	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-11 - ALTERNATIVE 3C, CASE 3, COST SUMMARY

001099

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3C
LOCATION: FEMP
CASE NO. 4

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT3CC4
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	118,801,400	0	576,800	119,178,200	84,986,900
2	OFF-SITE DISPOSAL	9,717,400	642,924,400	5,834,600	658,476,400	449,116,900
3	CONSOLIDATION AND COVER	49,462,200	0	20,254,800	69,717,000	38,730,000
4	BACKFILL	17,965,800	0	0	17,965,800	12,440,000
5	GMA EXTRACTION (6300 GPM)	10,804,700	27,585,800	1,643,000	40,033,500	27,863,700
6	GRND. WTR. & WASTE WTR.TREATMENT (6300 GPM)	47,177,700	319,987,000	25,715,000	392,859,700	253,879,300
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,556,500	98,585,500	0	100,144,000	68,509,000
TOTAL COSTS (ALTERNATIVE 3C - 4)		261,288,700	1,186,095,600	57,193,300	1,504,577,600	1,010,271,500
TOTAL ESCALATED COST					2,941,549,600	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-12 - ALTERNATIVE 3C, CASE 4, COST SUMMARY

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3C
LOCATION: FEMP
CASE NO. 5

SHEET: 1
DATE: 04-Nov-9
ESTD. BY: EST. DEP
CHKD. BY: F. FLOY
EST. FILE: ALT3CC
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	118,082,300	0	574,100	118,636,400	84,600,60
2	OFF-SITE DISPOSAL	9,631,400	637,234,800	5,783,000	652,649,200	446,144,40
3	CONSOLIDATION AND COVER	49,462,200	0	20,254,800	69,717,000	38,730,00
4	BACKFILL	18,294,900	0	0	18,294,900	12,868,80
5	GMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,70
6	GRND. WTR. & WASTE WTR.TREATMENT (6300 GPM)	47,177,700	319,967,000	25,715,000	392,859,700	253,879,30
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,70
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,00
9	CONTAMINATION SURVEYS	1,558,500	72,670,500	0	74,229,000	50,877,00
TOTAL COSTS (ALTERNATIVE 3C - 5)		260,982,700	1,154,491,000	57,139,000	1,472,622,700	988,507,60
TOTAL ESCALATED COST					2,886,039,500	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-13 - ALTERNATIVE 3C, CASE 5, COST SUMMARY

001101

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3C
LOCATION: FEMP
CASE NO. 6

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT3CC6
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	103,189,200	0	524,200	103,713,400	73,388,900
2	OFF-SITE DISPOSAL	9,631,400	637,234,800	5,783,000	652,649,200	445,144,400
3	CONSOLIDATION AND COVER	49,462,200	0	20,254,800	69,717,000	38,730,000
4	BACKFILL	17,227,700	0	0	17,227,700	11,980,600
5	GMA EXTRACTION (6300 GPM)	10,804,700	27,585,800	1,643,000	40,033,500	27,863,700
6	GRND. WTR. & WASTE WTR.TREATMENT (6300 GPM)	47,177,700	319,987,000	25,715,000	392,859,700	253,679,300
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,556,500	45,012,500	0	46,571,000	32,080,000
TOTAL COSTS (ALTERNATIVE 3C - 6)		245,052,400	1,126,833,000	57,089,100	1,426,974,500	957,791,600
TOTAL ESCALATED COST					2,812,860,900	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-14 - ALTERNATIVE 3C, CASE 6, COST SUMMARY

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 3C
LOCATION: FEMP
CASE NO. 7

SHEET: 1
DATE: 07-Nov-9
ESTD. BY: EST. DEP
CHKD. BY: F. FLOY
EST. FILE: ALT3CC
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	103,409,700	0	524,200	103,933,900	73,574,20
2	OFF-SITE DISPOSAL	9,831,400	637,234,800	5,783,000	652,849,200	445,144,40
3	CONSOLIDATION AND COVER	49,462,200	0	20,254,800	69,717,000	38,730,00
4	BACKFILL	16,836,800	0	0	16,836,800	11,708,80
5	OMA EXTRACTION (6300 GPM)	10,804,700	27,585,600	1,843,000	40,033,500	27,863,70
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,867,000	25,715,000	392,859,700	253,879,30
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,70
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,00
9	CONTAMINATION SURVEYS	1,558,500	45,402,500	0	46,961,000	32,325,00
TOTAL COSTS (ALTERNATIVE 3C - 7)		244,882,100	1,127,223,000	57,089,100	1,429,184,200	957,969,10
TOTAL ESCALATED COST					2,813,171,200	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-15 - ALTERNATIVE 3C, CASE 7, COST SUMMARY

001103

TABLE K.4-11

ALTERNATIVE 3C, CASE 3, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	3,149,600	2,437,900		5,587,500
1997	86,747,300	3,937,500		90,684,800
1998	20,602,400	38,627,500		59,229,900
1999		38,627,500		38,627,500
2000	20,602,400	52,655,900		73,258,300
2001		52,655,900		52,655,900
2002	20,602,400	52,655,900		73,258,300
2003		52,655,900		52,655,900
2004	20,602,400	52,655,900		73,258,300
2005		52,655,900		52,655,900
2006	20,602,400	52,655,900		73,258,300
2007		52,655,900		52,655,900
2008	20,602,400	52,655,900		73,258,300
2009		52,655,900		52,655,900
2010	20,602,400	52,655,900		73,258,300
2011		52,655,900		52,655,900
2012	20,602,400	52,655,900		73,258,300
2013		52,655,900		52,655,900
2014	20,602,400	52,655,900		73,258,300
2015		52,655,900		52,655,900
2016	20,602,400	52,655,900		73,258,300
2017		52,655,900		52,655,900
2018	20,602,400	52,655,900		73,258,300
2019		52,655,900		52,655,900
2020		13,714,500	9,919,200	23,633,700
2021		13,714,500	382,800	14,097,300
2022		13,714,500	382,800	14,097,300
2023		13,714,500	382,800	14,097,300
2024		13,714,500	382,800	14,097,300
2025			27,940,800	27,940,800
2026			382,800	382,800
2027			382,800	382,800
2028			382,800	382,800
2029			382,800	382,800
2030			382,800	382,800
2031			382,800	382,800
2032			382,800	382,800
2033			382,800	382,800
2034			382,800	382,800
2035			382,800	382,800
2036			382,800	382,800
2037			382,800	382,800
2038			382,800	382,800
2039			382,800	382,800
2040			382,800	382,800
2041			382,800	382,800
2042			382,800	382,800
2043			382,800	382,800
2044			382,800	382,800
2045			382,800	382,800
2046			382,800	382,800
2047			382,800	382,800
2048			382,800	382,800
2049			382,800	382,800
2050			382,800	382,800
2051			382,800	382,800
2052			382,800	382,800
2053			382,800	382,800
2054			382,800	382,800
2055			382,800	382,800
2056			382,800	382,800
2057			382,800	382,800
2058			382,800	382,800
2059			382,800	382,800
2060			382,800	382,800
2061			382,800	382,800
2062			382,800	382,800
2063			382,800	382,800
2064			382,800	382,800

TABLE K.4-11 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			382,800	382,800
2066			382,800	382,800
2067			382,800	382,800
2068			382,800	382,800
2069			382,800	382,800
2070			382,800	382,800
2071			382,800	382,800
2072			382,800	382,800
2073			382,800	382,800
2074			382,800	382,800
2075			382,800	382,800
2076			382,800	382,800
2077			382,800	382,800
2078			382,800	382,800
2079			382,800	382,800
2080			382,800	382,800
2081			382,800	382,800
2082			382,800	382,800
2083			382,800	382,800
2084			382,800	382,800
2085			382,800	382,800
2086			382,800	382,800
2087			382,800	382,800
2088			382,800	382,800
2089			382,800	382,800
2090			382,800	382,800
2091			382,800	382,800
2092			382,800	382,800
2093			382,800	382,800
2094			382,800	382,800
2095			382,800	382,800
2096			382,800	382,800
2097			382,800	382,800
2098			382,800	382,800
2099			382,800	382,800
2100			382,800	382,800
2101			382,800	382,800
2102			382,800	382,800
2103			382,800	382,800
2104			382,800	382,800
2105			382,800	382,800
2106			382,800	382,800
2107			382,800	382,800
2108			382,800	382,800
2109			382,800	382,800
2110			382,800	382,800
2111			382,800	382,800
2112			382,800	382,800
2113			382,800	382,800
2114			382,800	382,800
2115			382,800	382,800
2116			382,800	382,800
2117			382,800	382,800
2118			382,800	382,800
TOTALS	$316,523,300	$1,207,758,800	$74,991,600	$1,599,273,700

001105

TABLE K.4-12

ALTERNATIVE 3C, CASE 4, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	2,597,300	2,437,900		5,035,200
1997	83,823,300	3,937,700		87,761,000
1998	15,897,100	37,642,800		53,539,900
1999		37,642,800		37,642,800
2000	15,897,100	51,671,200		67,568,300
2001		51,671,200		51,671,200
2002	15,897,100	51,671,200		67,568,300
2003		51,671,200		51,671,200
2004	15,897,100	51,671,200		67,568,300
2005		51,671,200		51,671,200
2006	15,897,100	51,671,200		67,568,300
2007		51,671,200		51,671,200
2008	15,897,100	51,671,200		67,568,300
2009		51,671,200		51,671,200
2010	15,897,100	51,671,200		67,568,300
2011		51,671,200		51,671,200
2012	15,897,100	51,671,200		67,568,300
2013		51,671,200		51,671,200
2014	15,897,100	51,671,200		67,568,300
2015		51,671,200		51,671,200
2016	15,897,100	51,671,200		67,568,300
2017		51,671,200		51,671,200
2018	15,897,100	51,671,200		67,568,300
2019		51,671,200		51,671,200
2020		13,714,500	9,585,100	23,299,600
2021		13,714,500	204,600	13,919,100
2022		13,714,500	204,600	13,919,100
2023		13,714,500	204,600	13,919,100
2024		13,714,500	204,600	13,919,100
2025			27,762,000	27,762,000
2026			204,600	204,600
2027			204,600	204,600
2028			204,600	204,600
2029			204,600	204,600
2030			204,600	204,600
2031			204,600	204,600
2032			204,600	204,600
2033			204,600	204,600
2034			204,600	204,600
2035			204,600	204,600
2036			204,600	204,600
2037			204,600	204,600
2038			204,600	204,600
2039			204,600	204,600
2040			204,600	204,600
2041			204,600	204,600
2042			204,600	204,600
2043			204,600	204,600
2044			204,600	204,600
2045			204,600	204,600
2046			204,600	204,600
2047			204,600	204,600
2048			204,600	204,600
2049			204,600	204,600
2050			204,600	204,600
2051			204,600	204,600
2052			204,600	204,600
2053			204,600	204,600
2054			204,600	204,600
2055			204,600	204,600
2056			204,600	204,600
2057			204,600	204,600
2058			204,600	204,600
2059			204,600	204,600
2060			204,600	204,600
2061			204,600	204,600
2062			204,600	204,600
2063			204,600	204,600
2064			204,600	204,600

TABLE K.4-12 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			204,600	204,600
2066			204,600	204,600
2067			204,600	204,600
2068			204,600	204,600
2069			204,600	204,600
2070			204,600	204,600
2071			204,600	204,600
2072			204,600	204,600
2073			204,600	204,600
2074			204,600	204,600
2075			204,600	204,600
2076			204,600	204,600
2077			204,600	204,600
2078			204,600	204,600
2079			204,600	204,600
2080			204,600	204,600
2081			204,600	204,600
2082			204,600	204,600
2083			204,600	204,600
2084			204,600	204,600
2085			204,600	204,600
2086			204,600	204,600
2087			204,600	204,600
2088			204,600	204,600
2089			204,600	204,600
2090			204,600	204,600
2091			204,600	204,600
2092			204,600	204,600
2093			204,600	204,600
2094			204,600	204,600
2095			204,600	204,600
2096			204,600	204,600
2097			204,600	204,600
2098			204,600	204,600
2099			204,600	204,600
2100			204,600	204,600
2101			204,600	204,600
2102			204,600	204,600
2103			204,600	204,600
2104			204,600	204,600
2105			204,600	204,600
2106			204,600	204,600
2107			204,600	204,600
2108			204,600	204,600
2109			204,600	204,600
2110			204,600	204,600
2111			204,600	204,600
2112			204,600	204,600
2113			204,600	204,600
2114			204,600	204,600
2115			204,600	204,600
2116			204,600	204,600
2117			204,600	204,600
2118			204,600	204,600
TOTALS	$261,288,700	$1,186,093,600	$57,193,300	$1,504,577,600

001107

TABLE K.4-13

ALTERNATIVE 3C, CASE 5, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	2,594,300	2,437,900		5,032,200
1997	83,727,200	3,936,100		87,663,300
1998	15,879,200	36,206,300		52,085,500
1999		36,206,300		36,206,300
2000	15,879,200	50,234,700		66,113,900
2001		50,234,700		50,234,700
2002	15,879,200	50,234,700		66,113,900
2003		50,234,700		50,234,700
2004	15,879,200	50,234,700		66,113,900
2005		50,234,700		50,234,700
2006	15,879,200	50,234,700		66,113,900
2007		50,234,700		50,234,700
2008	15,879,200	50,234,700		66,113,900
2009		50,234,700		50,234,700
2010	15,879,200	50,234,700		66,113,900
2011		50,234,700		50,234,700
2012	15,879,200	50,234,700		66,113,900
2013		50,234,700		50,234,700
2014	15,879,200	50,234,700		66,113,900
2015		50,234,700		50,234,700
2016	15,879,200	50,234,700		66,113,900
2017		50,234,700		50,234,700
2018	15,879,200	50,234,700		66,113,900
2019		50,234,700		50,234,700
2020		13,714,500	9,530,800	23,245,300
2021		13,714,500	204,600	13,919,100
2022		13,714,500	204,600	13,919,100
2023		13,714,500	204,600	13,919,100
2024		13,714,500	204,600	13,919,100
2025			27,762,000	27,762,000
2026			204,600	204,600
2027			204,600	204,600
2028			204,600	204,600
2029			204,600	204,600
2030			204,600	204,600
2031			204,600	204,600
2032			204,600	204,600
2033			204,600	204,600
2034			204,600	204,600
2035			204,600	204,600
2036			204,600	204,600
2037			204,600	204,600
2038			204,600	204,600
2039			204,600	204,600
2040			204,600	204,600
2041			204,600	204,600
2042			204,600	204,600
2043			204,600	204,600
2044			204,600	204,600
2045			204,600	204,600
2046			204,600	204,600
2047			204,600	204,600
2048			204,600	204,600
2049			204,600	204,600
2050			204,600	204,600
2051			204,600	204,600
2052			204,600	204,600
2053			204,600	204,600
2054			204,600	204,600
2055			204,600	204,600
2056			204,600	204,600
2057			204,600	204,600
2058			204,600	204,600
2059			204,600	204,600
2060			204,600	204,600
2061			204,600	204,600
2062			204,600	204,600
2063			204,600	204,600
2064			204,600	204,600

001108

TABLE K.4-13 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			204,600	204,600
2066			204,600	204,600
2067			204,600	204,600
2068			204,600	204,600
2069			204,600	204,600
2070			204,600	204,600
2071			204,600	204,600
2072			204,600	204,600
2073			204,600	204,600
2074			204,600	204,600
2075			204,600	204,600
2076			204,600	204,600
2077			204,600	204,600
2078			204,600	204,600
2079			204,600	204,600
2080			204,600	204,600
2081			204,600	204,600
2082			204,600	204,600
2083			204,600	204,600
2084			204,600	204,600
2085			204,600	204,600
2086			204,600	204,600
2087			204,600	204,600
2088			204,600	204,600
2089			204,600	204,600
2090			204,600	204,600
2091			204,600	204,600
2092			204,600	204,600
2093			204,600	204,600
2094			204,600	204,600
2095			204,600	204,600
2096			204,600	204,600
2097			204,600	204,600
2098			204,600	204,600
2099			204,600	204,600
2100			204,600	204,600
2101			204,600	204,600
2102			204,600	204,600
2103			204,600	204,600
2104			204,600	204,600
2105			204,600	204,600
2106			204,600	204,600
2107			204,600	204,600
2108			204,600	204,600
2109			204,600	204,600
2110			204,600	204,600
2111			204,600	204,600
2112			204,600	204,600
2113			204,600	204,600
2114			204,600	204,600
2115			204,600	204,600
2116			204,600	204,600
2117			204,600	204,600
2118			204,600	204,600
TOTALS	$260,992,700	$1,154,491,000	$57,139,000	$1,472,622,700

001109

TABLE K.4-14

ALTERNATIVE 3C, CASE 6, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	2,434,900	2,437,900		4,872,800
1997	82,930,500	3,936,500		86,867,000
1998	14,517,000	34,949,100		49,466,100
1999		34,949,100		34,949,100
2000	14,517,000	48,977,500		63,494,500
2001		48,977,500		48,977,500
2002	14,517,000	48,977,500		63,494,500
2003		48,977,500		48,977,500
2004	14,517,000	48,977,500		63,494,500
2005		48,977,500		48,977,500
2006	14,517,000	48,977,500		63,494,500
2007		48,977,500		48,977,500
2008	14,517,000	48,977,500		63,494,500
2009		48,977,500		48,977,500
2010	14,517,000	48,977,500		63,494,500
2011		48,977,500		48,977,500
2012	14,517,000	48,977,500		63,494,500
2013		48,977,500		48,977,500
2014	14,517,000	48,977,500		63,494,500
2015		48,977,500		48,977,500
2016	14,517,000	48,977,500		63,494,500
2017		48,977,500		48,977,500
2018	14,517,000	48,977,500		63,494,500
2019		48,977,500		48,977,500
2020		13,714,500	9,480,900	23,195,400
2021		13,714,500	204,600	13,919,100
2022		13,714,500	204,600	13,919,100
2023		13,714,500	204,600	13,919,100
2024		13,714,500	204,600	13,919,100
2025			27,762,000	27,762,000
2026			204,600	204,600
2027			204,600	204,600
2028			204,600	204,600
2029			204,600	204,600
2030			204,600	204,600
2031			204,600	204,600
2032			204,600	204,600
2033			204,600	204,600
2034			204,600	204,600
2035			204,600	204,600
2036			204,600	204,600
2037			204,600	204,600
2038			204,600	204,600
2039			204,600	204,600
2040			204,600	204,600
2041			204,600	204,600
2042			204,600	204,600
2043			204,600	204,600
2044			204,600	204,600
2045			204,600	204,600
2046			204,600	204,600
2047			204,600	204,600
2048			204,600	204,600
2049			204,600	204,600
2050			204,600	204,600
2051			204,600	204,600
2052			204,600	204,600
2053			204,600	204,600
2054			204,600	204,600
2055			204,600	204,600
2056			204,600	204,600
2057			204,600	204,600
2058			204,600	204,600
2059			204,600	204,600
2060			204,600	204,600
2061			204,600	204,600
2062			204,600	204,600
2063			204,600	204,600
2064			204,600	204,600

TABLE K.4-14 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			204,600	204,600
2066			204,600	204,600
2067			204,600	204,600
2068			204,600	204,600
2069			204,600	204,600
2070			204,600	204,600
2071			204,600	204,600
2072			204,600	204,600
2073			204,600	204,600
2074			204,600	204,600
2075			204,600	204,600
2076			204,600	204,600
2077			204,600	204,600
2078			204,600	204,600
2079			204,600	204,600
2080			204,600	204,600
2081			204,600	204,600
2082			204,600	204,600
2083			204,600	204,600
2084			204,600	204,600
2085			204,600	204,600
2086			204,600	204,600
2087			204,600	204,600
2088			204,600	204,600
2089			204,600	204,600
2090			204,600	204,600
2091			204,600	204,600
2092			204,600	204,600
2093			204,600	204,600
2094			204,600	204,600
2095			204,600	204,600
2096			204,600	204,600
2097			204,600	204,600
2098			204,600	204,600
2099			204,600	204,600
2100			204,600	204,600
2101			204,600	204,600
2102			204,600	204,600
2103			204,600	204,600
2104			204,600	204,600
2105			204,600	204,600
2106			204,600	204,600
2107			204,600	204,600
2108			204,600	204,600
2109			204,600	204,600
2110			204,600	204,600
2111			204,600	204,600
2112			204,600	204,600
2113			204,600	204,600
2114			204,600	204,600
2115			204,600	204,600
2116			204,600	204,600
2117			204,600	204,600
2118			204,600	204,600
TOTALS	$245,052,400	$1,126,833,000	$57,089,100	$1,428,974,500

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TABLE K.4-15

ALTERNATIVE 3C, CASE 7, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	2,273,600	2,437,900		4,711,500
1997	82,124,000	3,937,100		86,061,100
1998	14,589,500	34,966,800		49,556,300
1999		34,966,800		34,966,800
2000	14,589,500	48,995,200		63,584,700
2001		48,995,200		48,995,200
2002	14,589,500	48,995,200		63,584,700
2003		48,995,200		48,995,200
2004	14,589,500	48,995,200		63,584,700
2005		48,995,200		48,995,200
2006	14,589,500	48,995,200		63,584,700
2007		48,995,200		48,995,200
2008	14,589,500	48,995,200		63,584,700
2009		48,995,200		48,995,200
2010	14,589,500	48,995,200		63,584,700
2011		48,995,200		48,995,200
2012	14,589,500	48,995,200		63,584,700
2013		48,995,200		48,995,200
2014	14,589,500	48,995,200		63,584,700
2015		48,995,200		48,995,200
2016	14,589,500	48,995,200		63,584,700
2017		48,995,200		48,995,200
2018	14,589,500	48,995,200		63,584,700
2019		48,995,200		48,995,200
2020		13,714,500	9,480,900	23,195,400
2021		13,714,500	204,600	13,919,100
2022		13,714,500	204,600	13,919,100
2023		13,714,500	204,600	13,919,100
2024		13,714,500	204,600	13,919,100
2025			27,762,000	27,762,000
2026			204,600	204,600
2027			204,600	204,600
2028			204,600	204,600
2029			204,600	204,600
2030			204,600	204,600
2031			204,600	204,600
2032			204,600	204,600
2033			204,600	204,600
2034			204,600	204,600
2035			204,600	204,600
2036			204,600	204,600
2037			204,600	204,600
2038			204,600	204,600
2039			204,600	204,600
2040			204,600	204,600
2041			204,600	204,600
2042			204,600	204,600
2043			204,600	204,600
2044			204,600	204,600
2045			204,600	204,600
2046			204,600	204,600
2047			204,600	204,600
2048			204,600	204,600
2049			204,600	204,600
2050			204,600	204,600
2051			204,600	204,600
2052			204,600	204,600
2053			204,600	204,600
2054			204,600	204,600
2055			204,600	204,600
2056			204,600	204,600
2057			204,600	204,600
2058			204,600	204,600
2059			204,600	204,600
2060			204,600	204,600
2061			204,600	204,600
2062			204,600	204,600
2063			204,600	204,600
2064			204,600	204,600

001112

TABLE K.4-15 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			204,600	204,600
2066			204,600	204,600
2067			204,600	204,600
2068			204,600	204,600
2069			204,600	204,600
2070			204,600	204,600
2071			204,600	204,600
2072			204,600	204,600
2073			204,600	204,600
2074			204,600	204,600
2075			204,600	204,600
2076			204,600	204,600
2077			204,600	204,600
2078			204,600	204,600
2079			204,600	204,600
2080			204,600	204,600
2081			204,600	204,600
2082			204,600	204,600
2083			204,600	204,600
2084			204,600	204,600
2085			204,600	204,600
2086			204,600	204,600
2087			204,600	204,600
2088			204,600	204,600
2089			204,600	204,600
2090			204,600	204,600
2091			204,600	204,600
2092			204,600	204,600
2093			204,600	204,600
2094			204,600	204,600
2095			204,600	204,600
2096			204,600	204,600
2097			204,600	204,600
2098			204,600	204,600
2099			204,600	204,600
2100			204,600	204,600
2101			204,600	204,600
2102			204,600	204,600
2103			204,600	204,600
2104			204,600	204,600
2105			204,600	204,600
2106			204,600	204,600
2107			204,600	204,600
2108			204,600	204,600
2109			204,600	204,600
2110			204,600	204,600
2111			204,600	204,600
2112			204,600	204,600
2113			204,600	204,600
2114			204,600	204,600
2115			204,600	204,600
2116			204,600	204,600
2117			204,600	204,600
2118			204,600	204,600
TOTALS	$244,882,100	$1,127,223,000	$57,089,100	$1,429,194,200

001113

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 4A
LOCATION: FEMP
CASE NO. 8

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT4AC8
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	116,062,300	0	574,100	116,636,400	84,600,600
2	OFF-SITE DISPOSAL	585,600	22,950,000	351,600	23,887,200	16,325,000
3	ON-SITE DISPOSAL CELL	271,682,900	0	46,937,100	318,620,000	200,564,000
4	BACKFILL	20,338,700	0	0	20,338,700	14,090,600
5	OMA EXTRACTION (6300 GPM)	10,604,700	27,585,600	1,843,000	40,033,500	27,883,700
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,987,000	25,715,000	392,859,700	253,879,300
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,556,500	73,632,500	0	75,191,000	51,532,000
TOTAL COSTS (ALTERNATIVE 4A - 8)		476,411,400	541,188,200	78,389,900	1,095,969,500	723,598,900
TOTAL ESCALATED COST					2,619,770,300	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-16 - ALTERNATIVE 4A, CASE 8, COST SUMMARY

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 4A
LOCATION: FEMP
CASE NO. 9

SHEET: 1
DATE: 04-Nov-
ESTD. BY: EST. DE
CHKD. BY: F. FLO
EST. FILE: ALT4A
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	103,189,200	0	524,200	103,713,400	73,388,9
2	OFF-SITE DISPOSAL	565,600	22,950,000	351,600	23,867,200	16,325,0
3	ON-SITE DISPOSAL CELL	271,882,900	0	46,937,100	318,820,000	200,564,0
4	BACKFILL	21,639,200	0	0	21,639,200	15,049,2
5	OMA EXTRACTION (6300 GPM)	10,604,700	27,585,600	1,843,000	40,033,500	27,883,7
6	GRND. WTR. & WASTE WTR.TREATMENT (6300 GPM)	47,177,700	319,867,000	25,715,000	392,859,700	253,879,3
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,198,7
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,0
9	CONTAMINATION SURVEYS	1,558,500	45,975,500	0	47,534,000	32,715,0
TOTAL COSTS (ALTERNATIVE 4A - 9)		462,836,800	513,511,200	78,340,000	1,054,880,000	694,529,8
TOTAL ESCALATED COST					2,550,596,800	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-17 - ALTERNATIVE 4A, CASE 9, COST SUMMARY

001115

TABLE K.4-16

ALTERNATIVE 4A, CASE 8, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	4,748,500	2,437,900		7,186,400
1997	85,996,300	3,937,700		89,934,000
1998	35,060,600	8,328,100		43,388,700
1999		8,328,100		8,328,100
2000	35,060,600	22,356,300		57,416,900
2001		22,356,300		22,356,300
2002	35,060,600	22,356,300		57,416,900
2003		22,356,300		22,356,300
2004	35,060,600	22,356,300		57,416,900
2005		22,356,300		22,356,300
2006	35,060,600	22,356,300		57,416,900
2007		22,356,300		22,356,300
2008	35,060,600	22,356,300		57,416,900
2009		22,356,300		22,356,300
2010	35,060,600	22,356,300		57,416,900
2011		22,356,300		22,356,300
2012	35,060,600	22,356,300		57,416,900
2013		22,356,300		22,356,300
2014	35,060,600	22,356,300		57,416,900
2015		22,356,300		22,356,300
2016	35,060,600	22,356,300		57,416,900
2017		22,356,300		22,356,300
2018	35,060,600	22,356,300		57,416,900
2019		22,356,300		22,356,300
2020		13,714,500	4,370,100	18,084,600
2021		13,714,500	474,100	14,188,600
2022		13,714,500	474,100	14,188,600
2023		13,714,500	474,100	14,188,600
2024		13,714,500	474,100	14,188,600
2025			28,032,100	28,032,100
2026			474,100	474,100
2027			474,100	474,100
2028			474,100	474,100
2029			474,100	474,100
2030			474,100	474,100
2031			474,100	474,100
2032			474,100	474,100
2033			474,100	474,100
2034			474,100	474,100
2035			474,100	474,100
2036			474,100	474,100
2037			474,100	474,100
2038			474,100	474,100
2039			474,100	474,100
2040			474,100	474,100
2041			474,100	474,100
2042			474,100	474,100
2043			474,100	474,100
2044			474,100	474,100
2045			474,100	474,100
2046			474,100	474,100
2047			474,100	474,100
2048			474,100	474,100
2049			474,100	474,100
2050			474,100	474,100
2051			474,100	474,100
2052			474,100	474,100
2053			474,100	474,100
2054			474,100	474,100
2055			474,100	474,100
2056			474,100	474,100
2057			474,100	474,100
2058			474,100	474,100
2059			474,100	474,100
2060			474,100	474,100
2061			474,100	474,100
2062			474,100	474,100
2063			474,100	474,100
2064			474,100	474,100

TABLE K.4-16 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			474,100	474,100
2066			474,100	474,100
2067			474,100	474,100
2068			474,100	474,100
2069			474,100	474,100
2070			474,100	474,100
2071			474,100	474,100
2072			474,100	474,100
2073			474,100	474,100
2074			474,100	474,100
2075			474,100	474,100
2076			474,100	474,100
2077			474,100	474,100
2078			474,100	474,100
2079			474,100	474,100
2080			474,100	474,100
2081			474,100	474,100
2082			474,100	474,100
2083			474,100	474,100
2084			474,100	474,100
2085			474,100	474,100
2086			474,100	474,100
2087			474,100	474,100
2088			474,100	474,100
2089			474,100	474,100
2090			474,100	474,100
2091			474,100	474,100
2092			474,100	474,100
2093			474,100	474,100
2094			474,100	474,100
2095			474,100	474,100
2096			474,100	474,100
2097			474,100	474,100
2098			474,100	474,100
2099			474,100	474,100
2100			474,100	474,100
2101			474,100	474,100
2102			474,100	474,100
2103			474,100	474,100
2104			474,100	474,100
2105			474,100	474,100
2106			474,100	474,100
2107			474,100	474,100
2108			474,100	474,100
2109			474,100	474,100
2110			474,100	474,100
2111			474,100	474,100
2112			474,100	474,100
2113			474,100	474,100
2114			474,100	474,100
2115			474,100	474,100
2116			474,100	474,100
2117			474,100	474,100
2118			474,100	474,100
TOTALS	$476,411,400	$541,168,200	$78,389,900	$1,095,969,500

001117

TABLE K.4-17

ALTERNATIVE 4A, CASE 9, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	4,612,800	2,437,900		7,050,700
1997	85,317,200	3,937,100		89,254,300
1998	33,900,800	7,070,900		40,971,700
1999		7,070,900		7,070,900
2000	33,900,800	21,099,200		55,000,000
2001		21,099,200		21,099,200
2002	33,900,800	21,099,200		55,000,000
2003		21,099,200		21,099,200
2004	33,900,800	21,099,200		55,000,000
2005		21,099,200		21,099,200
2006	33,900,800	21,099,200		55,000,000
2007		21,099,200		21,099,200
2008	33,900,800	21,099,200		55,000,000
2009		21,099,200		21,099,200
2010	33,900,800	21,099,200		55,000,000
2011		21,099,200		21,099,200
2012	33,900,800	21,099,200		55,000,000
2013		21,099,200		21,099,200
2014	33,900,800	21,099,200		55,000,000
2015		21,099,200		21,099,200
2016	33,900,800	21,099,200		55,000,000
2017		21,099,200		21,099,200
2018	33,900,800	21,099,200		55,000,000
2019		21,099,200		21,099,200
2020		13,714,500	4,320,200	18,034,700
2021		13,714,500	474,100	14,188,600
2022		13,714,500	474,100	14,188,600
2023		13,714,500	474,100	14,188,600
2024		13,714,500	474,100	14,188,600
2025			28,032,100	28,032,100
2026			474,100	474,100
2027			474,100	474,100
2028			474,100	474,100
2029			474,100	474,100
2030			474,100	474,100
2031			474,100	474,100
2032			474,100	474,100
2033			474,100	474,100
2034			474,100	474,100
2035			474,100	474,100
2036			474,100	474,100
2037			474,100	474,100
2038			474,100	474,100
2039			474,100	474,100
2040			474,100	474,100
2041			474,100	474,100
2042			474,100	474,100
2043			474,100	474,100
2044			474,100	474,100
2045			474,100	474,100
2046			474,100	474,100
2047			474,100	474,100
2048			474,100	474,100
2049			474,100	474,100
2050			474,100	474,100
2051			474,100	474,100
2052			474,100	474,100
2053			474,100	474,100
2054			474,100	474,100
2055			474,100	474,100
2056			474,100	474,100
2057			474,100	474,100
2058			474,100	474,100
2059			474,100	474,100
2060			474,100	474,100
2061			474,100	474,100
2062			474,100	474,100
2063			474,100	474,100
2064			474,100	474,100

TABLE K.4-17 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			474,100	474,100
2066			474,100	474,100
2067			474,100	474,100
2068			474,100	474,100
2069			474,100	474,100
2070			474,100	474,100
2071			474,100	474,100
2072			474,100	474,100
2073			474,100	474,100
2074			474,100	474,100
2075			474,100	474,100
2076			474,100	474,100
2077			474,100	474,100
2078			474,100	474,100
2079			474,100	474,100
2080			474,100	474,100
2081			474,100	474,100
2082			474,100	474,100
2083			474,100	474,100
2084			474,100	474,100
2085			474,100	474,100
2086			474,100	474,100
2087			474,100	474,100
2088			474,100	474,100
2089			474,100	474,100
2090			474,100	474,100
2091			474,100	474,100
2092			474,100	474,100
2093			474,100	474,100
2094			474,100	474,100
2095			474,100	474,100
2096			474,100	474,100
2097			474,100	474,100
2098			474,100	474,100
2099			474,100	474,100
2100			474,100	474,100
2101			474,100	474,100
2102			474,100	474,100
2103			474,100	474,100
2104			474,100	474,100
2105			474,100	474,100
2106			474,100	474,100
2107			474,100	474,100
2108			474,100	474,100
2109			474,100	474,100
2110			474,100	474,100
2111			474,100	474,100
2112			474,100	474,100
2113			474,100	474,100
2114			474,100	474,100
2115			474,100	474,100
2116			474,100	474,100
2117			474,100	474,100
2118			474,100	474,100
TOTALS	$462,838,800	$513,511,200	$78,340,000	$1,054,690,000

001119

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 4C
LOCATION: FEMP
CASE NO. 8

SHEET: 1
DATE: 04-Nov-94
ESTD. BY: EST. DEPT
CHKD. BY: F. FLOYD
EST. FILE: ALT4CC8
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	116,062,300	0	574,100	116,636,400	84,600,600
2	OFF-SITE DISPOSAL	9,631,400	637,234,800	5,783,000	652,649,200	445,144,400
3	CONSOLIDATION AND COVER	49,462,200	0	20,254,800	69,717,000	38,730,000
4	BACKFILL	20,338,700	0	0	20,338,700	14,090,600
5	GMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,700
6	GRND. WTR. & WASTE WTR.TREATMENT (6300 GPM)	47,177,700	319,867,000	25,715,000	392,859,700	253,879,300
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,700
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,000
9	CONTAMINATION SURVEYS	1,558,500	73,632,500	0	75,191,000	51,532,000
TOTAL COSTS (ALTERNATIVE 4C - 8)		263,036,500	1,155,453,000	57,139,000	1,475,626,500	990,584,300
TOTAL ESCALATED COST					2,891,172,300	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-18 - ALTERNATIVE 4C, CASE 8, COST SUMMARY

ALTERNATIVE COST SUMMARY

ALTERNATIVE: 4C
LOCATION: FEMP
CASE NO. 9

SHEET: 1
DATE: 04-Nov-
ESTD. BY: EST. DE
CHKD. BY: F. FLO
EST. FILE: ALT4C
REV #: 1

COMPONENT ESTIMATE #	COMPONENT DESCRIPTION	CONSTRUCTION COSTS	REMEDIAL O&M COSTS	POST-REM. COSTS	TOTAL COSTS	NET PW COSTS
1	SOIL EXCAVATION	103,169,200	0	524,200	103,713,400	73,388,9
2	OFF-SITE DISPOSAL	9,631,400	637,234,800	5,783,000	652,649,200	445,144,4
3	CONSOLIDATION AND COVER	49,462,200	0	20,254,800	69,717,000	38,730,0
4	BACKFILL	21,639,200	0	0	21,639,200	15,049,2
5	GMA EXTRACTION (6300 GPM)	10,604,700	27,585,800	1,843,000	40,033,500	27,863,7
6	GRND. WTR. & WASTE WTR. TREATMENT (6300 GPM)	47,177,700	319,987,000	25,715,000	392,859,700	253,879,3
7	CENTRAL STORAGE FACILITY	6,201,000	25,032,900	2,969,100	34,203,000	24,199,7
8	ENVIRONMENTAL MONITORING	0	72,000,000	0	72,000,000	50,544,0
9	CONTAMINATION SURVEYS	1,558,500	45,975,500	0	47,534,000	32,715,0
TOTAL COSTS (ALTERNATIVE 4C - 9)		249,463,900	1,127,796,000	57,089,100	1,434,349,000	961,515,2
TOTAL ESCALATED COST					2,822,000,600	

Note: All costs includes Risk Budget and Contingency

FIGURE K.4-19 - ALTERNATIVE 4C, CASE 9, COST SUMMARY

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TABLE K.4-18

ALTERNATIVE 4C, CASE 8, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	2,614,700	2,437,900		5,052,600
1997	84,710,000	3,937,100		88,647,100
1998	15,973,800	36,249,800		52,223,600
1999		36,249,800		36,249,800
2000	15,973,800	50,278,400		66,252,200
2001		50,278,400		50,278,400
2002	15,973,800	50,278,400		66,252,200
2003		50,278,400		50,278,400
2004	15,973,800	50,278,400		66,252,200
2005		50,278,400		50,278,400
2006	15,973,800	50,278,400		66,252,200
2007		50,278,400		50,278,400
2008	15,973,800	50,278,400		66,252,200
2009		50,278,400		50,278,400
2010	15,973,800	50,278,400		66,252,200
2011		50,278,400		50,278,400
2012	15,973,800	50,278,400		66,252,200
2013		50,278,400		50,278,400
2014	15,973,800	50,278,400		66,252,200
2015		50,278,400		50,278,400
2016	15,973,800	50,278,400		66,252,200
2017		50,278,400		50,278,400
2018	15,973,800	50,278,400		66,252,200
2019		50,278,400		50,278,400
2020		13,714,500	9,530,200	23,244,700
2021		13,714,500	204,600	13,919,100
2022		13,714,500	204,600	13,919,100
2023		13,714,500	204,600	13,919,100
2024		13,714,500	204,600	13,919,100
2025			27,762,600	27,762,600
2026			204,600	204,600
2027			204,600	204,600
2028			204,600	204,600
2029			204,600	204,600
2030			204,600	204,600
2031			204,600	204,600
2032			204,600	204,600
2033			204,600	204,600
2034			204,600	204,600
2035			204,600	204,600
2036			204,600	204,600
2037			204,600	204,600
2038			204,600	204,600
2039			204,600	204,600
2040			204,600	204,600
2041			204,600	204,600
2042			204,600	204,600
2043			204,600	204,600
2044			204,600	204,600
2045			204,600	204,600
2046			204,600	204,600
2047			204,600	204,600
2048			204,600	204,600
2049			204,600	204,600
2050			204,600	204,600
2051			204,600	204,600
2052			204,600	204,600
2053			204,600	204,600
2054			204,600	204,600
2055			204,600	204,600
2056			204,600	204,600
2057			204,600	204,600
2058			204,600	204,600
2059			204,600	204,600
2060			204,600	204,600
2061			204,600	204,600
2062			204,600	204,600
2063			204,600	204,600
2064			204,600	204,600

TABLE K.4-18 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			204,600	204,600
2066			204,600	204,600
2067			204,600	204,600
2068			204,600	204,600
2069			204,600	204,600
2070			204,600	204,600
2071			204,600	204,600
2072			204,600	204,600
2073			204,600	204,600
2074			204,600	204,600
2075			204,600	204,600
2076			204,600	204,600
2077			204,600	204,600
2078			204,600	204,600
2079			204,600	204,600
2080			204,600	204,600
2081			204,600	204,600
2082			204,600	204,600
2083			204,600	204,600
2084			204,600	204,600
2085			204,600	204,600
2086			204,600	204,600
2087			204,600	204,600
2088			204,600	204,600
2089			204,600	204,600
2090			204,600	204,600
2091			204,600	204,600
2092			204,600	204,600
2093			204,600	204,600
2094			204,600	204,600
2095			204,600	204,600
2096			204,600	204,600
2097			204,600	204,600
2098			204,600	204,600
2099			204,600	204,600
2100			204,600	204,600
2101			204,600	204,600
2102			204,600	204,600
2103			204,600	204,600
2104			204,600	204,600
2105			204,600	204,600
2106			204,600	204,600
2107			204,600	204,600
2108			204,600	204,600
2109			204,600	204,600
2110			204,600	204,600
2111			204,600	204,600
2112			204,600	204,600
2113			204,600	204,600
2114			204,600	204,600
2115			204,600	204,600
2116			204,600	204,600
2117			204,600	204,600
2118			204,600	204,600
TOTALS	$263,036,500	$1,155,453,000	$57,139,000	$1,475,628,500

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TABLE K.4-19

ALTERNATIVE 4C, CASE 9, LIFE-CYCLE COSTS

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
1994				
1995		2,437,900		2,437,900
1996	2,479,000	2,437,900		4,916,900
1997	83,150,900	3,937,900		87,088,800
1998	14,894,000	34,992,900		49,886,900
1999		34,992,900		34,992,900
2000	14,894,000	49,021,200		63,915,200
2001		49,021,200		49,021,200
2002	14,894,000	49,021,200		63,915,200
2003		49,021,200		49,021,200
2004	14,894,000	49,021,200		63,915,200
2005		49,021,200		49,021,200
2006	14,894,000	49,021,200		63,915,200
2007		49,021,200		49,021,200
2008	14,894,000	49,021,200		63,915,200
2009		49,021,200		49,021,200
2010	14,894,000	49,021,200		63,915,200
2011		49,021,200		49,021,200
2012	14,894,000	49,021,200		63,915,200
2013		49,021,200		49,021,200
2014	14,894,000	49,021,200		63,915,200
2015		49,021,200		49,021,200
2016	14,894,000	49,021,200		63,915,200
2017		49,021,200		49,021,200
2018	14,894,000	49,021,200		63,915,200
2019		49,021,200		49,021,200
2020		13,714,500	9,480,300	23,194,800
2021		13,714,500	204,600	13,919,100
2022		13,714,500	204,600	13,919,100
2023		13,714,500	204,600	13,919,100
2024		13,714,500	204,600	13,919,100
2025			27,762,600	27,762,600
2026			204,600	204,600
2027			204,600	204,600
2028			204,600	204,600
2029			204,600	204,600
2030			204,600	204,600
2031			204,600	204,600
2032			204,600	204,600
2033			204,600	204,600
2034			204,600	204,600
2035			204,600	204,600
2036			204,600	204,600
2037			204,600	204,600
2038			204,600	204,600
2039			204,600	204,600
2040			204,600	204,600
2041			204,600	204,600
2042			204,600	204,600
2043			204,600	204,600
2044			204,600	204,600
2045			204,600	204,600
2046			204,600	204,600
2047			204,600	204,600
2048			204,600	204,600
2049			204,600	204,600
2050			204,600	204,600
2051			204,600	204,600
2052			204,600	204,600
2053			204,600	204,600
2054			204,600	204,600
2055			204,600	204,600
2056			204,600	204,600
2057			204,600	204,600
2058			204,600	204,600
2059			204,600	204,600
2060			204,600	204,600
2061			204,600	204,600
2062			204,600	204,600
2063			204,600	204,600
2064			204,600	204,600

TABLE K.4-19 (Continued)

Year	CONSTRUCTION	REMEDIAL OPERATIONS & MAINTENANCE	POST-REMEDIAL OPERATIONS & MAINTENANCE	TOTAL ANNUAL COST (CONSTANT) (DOLLAR)
2065			204,600	204,600
2066			204,600	204,600
2067			204,600	204,600
2068			204,600	204,600
2069			204,600	204,600
2070			204,600	204,600
2071			204,600	204,600
2072			204,600	204,600
2073			204,600	204,600
2074			204,600	204,600
2075			204,600	204,600
2076			204,600	204,600
2077			204,600	204,600
2078			204,600	204,600
2079			204,600	204,600
2080			204,600	204,600
2081			204,600	204,600
2082			204,600	204,600
2083			204,600	204,600
2084			204,600	204,600
2085			204,600	204,600
2086			204,600	204,600
2087			204,600	204,600
2088			204,600	204,600
2089			204,600	204,600
2090			204,600	204,600
2091			204,600	204,600
2092			204,600	204,600
2093			204,600	204,600
2094			204,600	204,600
2095			204,600	204,600
2096			204,600	204,600
2097			204,600	204,600
2098			204,600	204,600
2099			204,600	204,600
2100			204,600	204,600
2101			204,600	204,600
2102			204,600	204,600
2103			204,600	204,600
2104			204,600	204,600
2105			204,600	204,600
2106			204,600	204,600
2107			204,600	204,600
2108			204,600	204,600
2109			204,600	204,600
2110			204,600	204,600
2111			204,600	204,600
2112			204,600	204,600
2113			204,600	204,600
2114			204,600	204,600
2115			204,600	204,600
2116			204,600	204,600
2117			204,600	204,600
2118			204,600	204,600
TOTALS	$249,463,900	$1,127,796,000	$57,089,100	$1,434,349,000

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APPENDIX L

DETAILED REMEDIAL ALTERNATIVE COMPONENT DESCRIPTIONS

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LIST OF ACRONYMS

AWWT	advanced waste water treatment (facility)
BDN-ETS	biodenitrification-effluent treatment system
BDN-HNT	biodenitrificaiton-high nitrate tank
BSL	biodenitrificaiton surge lagoon
CERCLA	Comprehensive Environmental Response, Compensation and Liabilty Act
COC	constituent of concern
CSF	central storage facility
DOE	US Department of Energy
DOT	US Department of Transporation
EPA	US Environmental Protection Agency
FEMP	Fernald Environmental Management Project
FS	feasibility study
GTF	groundwater treatment facility
HDPE	high-density polyethylene
HEPA	high efficiency particulate air (filter)
HI	hazard index
IAWWT	interim advanced wastewater treament
LDR	land disposal restriction
MCL	maximum concentration level
NPDES	National Pollutant Discharge Elimination System
NTS	Nevada Test Site
OD	outer diameter
PCB	polychlorinated biphenyl
PRL	preliminary remediation level
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
ROD	record of decision
SCQ	Sitewide CERCLA Quality Assurance Project Plan
SEP	supplemental environmental project
SPIT	South Plume interim treatment
SWRB	storm water retention basin
TCLP	toxicity characteristic leachate procedure

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LIST OF ACRONYMS
(Continued)

VISITT	vendor information system for innovative treatment technologies (database)
VOC	volatile organic compound
WAC	waste acceptance criteria

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OVERVIEW

The Operable Unit 5 remedial alternatives are comprised of a combination of the following remedial components:

- Soil excavation
  - Soil washing
  - Off-site disposal
  - Stabilization
  - Consolidation
  - On-property disposal cell
  - Backfill
  - Groundwater monitoring
  - Great Miami Aquifer extraction
  - Central storage facility

The remedial component detailed descriptions further define the building blocks of each remedial alternative with respect to the technologies to be used and the performance requirements associated with those technologies. The detailed descriptions include a functional description of each remedial component and a combination of the following preliminary engineering documents:

- Process or block flow diagram
- Major equipment list
- Site plan
- Cross-section
- Typical well design

The remedial components are described in detail in the following sections.

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L.1.0 SOIL EXCAVATION

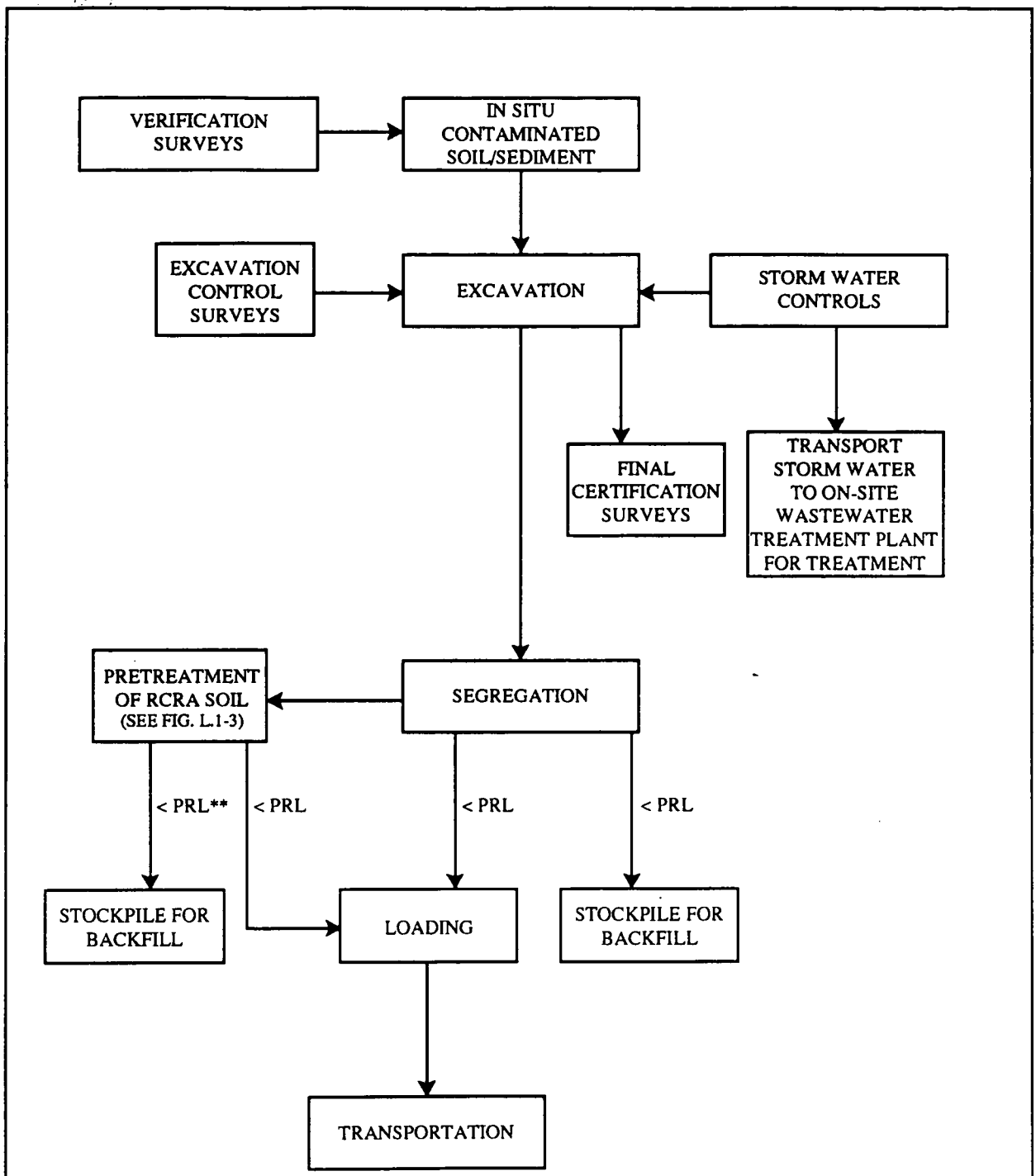
Contaminated soil exceeding preliminary remediation levels (PRLs) for each alternative would be excavated using conventional earth moving equipment. Figure L.1-1 presents a flow diagram depicting the major activities associated with soil excavation.

L.1.1 VERIFICATION SURVEYS

The objective of the verification survey is to provide sufficient data to design and implement the soil excavation process. The excavation footprints presented in Section 2.0 of the Feasibility Study (FS) were based upon a kriging analysis of the available uranium data for soil and sediment collected during the Remedial Investigation (RI) and other environmental studies conducted at the Fernald Environmental Management Project (FEMP). The kriging analysis was supplemented by manual interpretations of data for other constituents of concern (COCs), which were presented in the Operable Unit 5 RI Report. While this distribution of samples is appropriate to establish the approximate limits of excavation and the volumes of material to support the evaluation of the remedial alternatives, it is not sufficient to design an effective remediation program. For instance, the data points showing FEMP contamination are generally separated by 3000 feet or more. The FEMP has estimated that the minimum area of land required to fully develop the resident farmer scenario, used for the derivation of PRLs, is from five to 20 acres. The available RI data is insufficient to establish the average concentration of contaminants distributed over individual five to 20 acre areas. Such resolution is required to ensure that private land which exceeds the risk-based PRLs is adequately addressed while areas not contaminated will not be unduly disturbed.

The cost of excavating and treating or disposing of contaminated soil is very high. Therefore, it is vital to the success of the remedial action to be sure that only contaminated materials are removed and, at the same time, be sure that all the material exceeding the final remediation levels are removed. Further, while the RI Report data indicate the general vertical and lateral extent of contamination in sufficient detail to be sure that the materials are present, they do not define the vertical extent of contamination sufficiently to be used in directing conventional excavation equipment. The verification sampling program, as conceptually outlined here, would provide data at a sufficient level of detail to make these decisions. The verification sampling program would be finalized as part of the remedial design and remedial action process.

The nature of the contamination, the method of deposition and the subsurface conditions of the area are factors that are involved in the design of the verification sampling. Sampling to determine the volume of soil to be excavated in the off-property areas where the contaminants arrived by air deposition will be different from sampling in the production area where acidic fluids were spilled. Because of such variability, the guidance on statistical sampling approaches and methods for



**PRELIMINARY REMEDIATION LEVEL

NOTE:
COLLECTED STORM WATER AND PERCHED WATER SUSPECTED OF CONTAINING CONSTITUENTS LISTED BY THE RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) WILL BE SEGREGATED AND PRE-TREATED BEFORE DELIVERY TO THE ADVANCED WASTEWATER TREATMENT FACILITY.

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FIGURE L.1-1. SOIL EXCAVATION FLOW DIAGRAM

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performing such surveys are established within a technical memorandum issued by the U.S. Environmental Protection Agency (EPA) entitled "Methods for Evaluating the Attainment of Cleanup Standards." Using this guidance, a consistent conceptual approach has been developed for verification sampling of affected areas off FEMP property, on-property areas outside the production area and waste storage areas, and on-property areas within the production and waste storage areas following source removal activities. Generally the strategy would be to survey boundary areas to define the limits of the excavation, remove all material within the boundaries, and conduct a certification sampling program before an area is backfilled.

Analytical detection levels and procedures may range from hand held field instruments to laboratory procedures. The selection of the analytical precision levels will be dictated by the establishment of the final remediation levels in the Record of Decision (ROD). The collection of quality control samples would be commensurate with the analytical procedures and consistent with the Sitewide CERCLA Quality Assurance Project Plan (SCQ). Where possible, instrument measurements with hand-held radiological detection instruments would be taken at each survey location. When instrument measurements are statistically higher than background and bracket PRL concentrations, minimal or no samples would be collected to verify the extent of the excavation. Under these conditions, the instrument data would be used to determine the area to be excavated.

As a continuation of the K_i investigation, which has indicated that radionuclides present in soil outside the FEMP-controlled areas are essentially immobile in the soil, approximately 10 percent of the samples collected in the verification sampling will be tested for leachability. This data will be used to support the waste characterization for disposal of the excavated material.

L.1.1.1 Off-Property Verification Survey

Verification surveys would be conducted, as required, to focus on the affected soil, sediment and other miscellaneous impacted areas located off the FEMP property. The verification program for sediment would be focused on Paddys Run and the Great Miami River. The miscellaneous impacted areas include the contaminated rubble and soil located adjacent to the FEMP outfall line at the Great Miami River and potentially affected soil beneath the retired outfall line.

Soil

RI data suggest that potentially an area as large as 11 square miles off the FEMP property may be above the PRLs for soil. The lateral extent of the impacted area is closely linked to the determination of the final remediation level. If the final cleanup level is established using the 10^{-6} risk level of 5 ppm for the resident farmer for affected off-property areas, it is estimated that over five million cubic yards of soil distributed over the 11-square-mile area of privately owned land would be affected. The concentration of uranium suspected to reside in the vast majority of this area is

estimated to be less than 6 to 8 ppm. At a final cleanup level approximating the 10^{-5} residual risk level to the resident farmer of 15 ppm, the area of impacted soil is estimated to be immediately adjacent to only the eastern and northern property lines of the FEMP. The volume of impacted soil at this target cleanup level is estimated to be approximately 400,000 cubic yards. Raising the cleanup level to permit approximately 50 ppm of uranium to remain in the affected soil would essentially eliminate the need for off-property excavation, with the exception of activities to address soil beneath the retired outfall line and the contaminated rubble and soil present adjacent to the outfall line discharge point.

As noted earlier, the appropriateness of specific analytical methods would change with the selection of the final cleanup level. For uranium, variations in the method of detection and analysis would be required if the PRL was reduced from the approximate 50 ppm level to the near background level of 5 ppm associated with the 10^{-6} risk level for the resident farmer. On the basis of work at the FEMP and other cleanup sites, the ability to use hand-held radiological detection instruments becomes increasingly difficult as the concentration in soil falls below 100 ppm. The practical limit of currently available hand-held, field-proven instruments is approximately 50 ppm for uranium. Detection at this level typically requires the use of fully shielded detectors (shielded FIDLER) with each measurement requiring a count time of 1 to 10 minutes. The ability to detect uranium in soil at low concentrations is affected by many conditions including: the type and distribution of radionuclides present in the soil; the efficiency of the detector; the moisture content of the soil; and the detection geometry. Therefore, below the range of 50 to 100 ppm of residual uranium in soil, verification sampling must be conducted followed by laboratory analysis of samples and statistical interpretation of the results. Similar limitations would be confronted in the detection of other radionuclides in soil. The available RI data suggest that the concentrations of other radionuclides, including radium and thorium, present in soil at the FEMP are generally below the detection capability of hand-held instruments. Some limited usage of hand-held radiological instruments may support the removal of impacted soil within the Operable Unit 1 and 4 areas.

For the nonradiological parameters, hand-held instrumentation could not be utilized, except for detecting volatile organics at relatively high concentrations. All verification and certification sampling performed off the FEMP property for non-radiological parameters is assumed to include either trailer-mounted or full laboratory analysis.

The off-property soil potentially impacted at the 10^{-6} risk level is distributed over a broad contiguous area, with isolated suspect areas located outside the contiguous area. The suspect areas are generally situated along low-lying areas such as drainage swales. These suspect areas generally had one to three sampling locations indicating residual concentrations within ± 10 percent of the PRL. The objective of the verification sampling program, in the event the 10^{-6} resident farmer risk level PRL is

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adopted as part of the selected remedy, would be to sample this relatively large off-property area to the extent necessary to define the outer limits of excavation, assuming excavation would be to a depth of six inches everywhere. Due to the size of the affected area, and the need to acquire access, the sampling of this area would be expected to require up to three years to complete.

For purposes of cost analysis in this FS, a conceptual sampling approach was adopted for the 10^{-6} risk level off-property footprint to determine if the average residual concentration exceeded the PRL in any 5-acre area. The general approach would be to initiate sampling at the suspected outer edge of the contaminated area as presented in the RI; the outer edge is an isoconcentration line dividing clean from contaminated samples. The location of this line is refined by successively sampling half way between clean and contaminated sample pairs.

Initially a sample would be collected approximately half way between the last RI sampling location that exhibits contamination greater than the PRL and those that do not for every pair of points which bracket the isoconcentration. Based upon the analyses of the first sample, a second sample would be collected half way between the samples that bracket the isoconcentration line. Given the spacing of the RI sampling locations, sampling would have to be repeated four times to define the boundary for an area less than 5 acres in size.

Figure L.1-2 illustrates the sampling sequence. The RI samples are indicated by an X for clean samples and an O for contaminated samples. The isoconcentration line defining the approximate limit of contamination is drawn between sampling locations with a dashed line. To determine the location of the first sample, a line is drawn between each RI sample pair. If the spacing between adjacent clean samples is greater than 5000 feet, an additional sampling line is drawn from a contaminated sample to bisect the distance between the clean samples. An initial sample, shown by a 1 in Figure L.1-2, is collected half way between each RI sample pair or at a distance of 1500 feet from the contaminated sample. The result of this initial sample is plotted on the map. If Sample 1 is greater than the PRL the second sample, shown as a 2 in Figure L.1-2, is taken half way between Sample 1 and the clean RI sample. If Sample 1 was less than the PRL the second sample is taken half way between Sample 1 and the contaminated RI sample. The results of Sample 2 are evaluated in the same manner as Sample 1. Sample 3 will be collected half way between Sample 2 and the adjacent clean or contaminated sample depending on the level of contamination in Sample 2. The refined isoconcentration line is shown as a solid line in Figure L.1-2 after the sampling distance has been halved four times.

Given that the RI samples are spaced approximately 3000 feet or more apart, it will require four samples to have a density of samples approximately 200 to 300 feet apart. A 5-acre area is

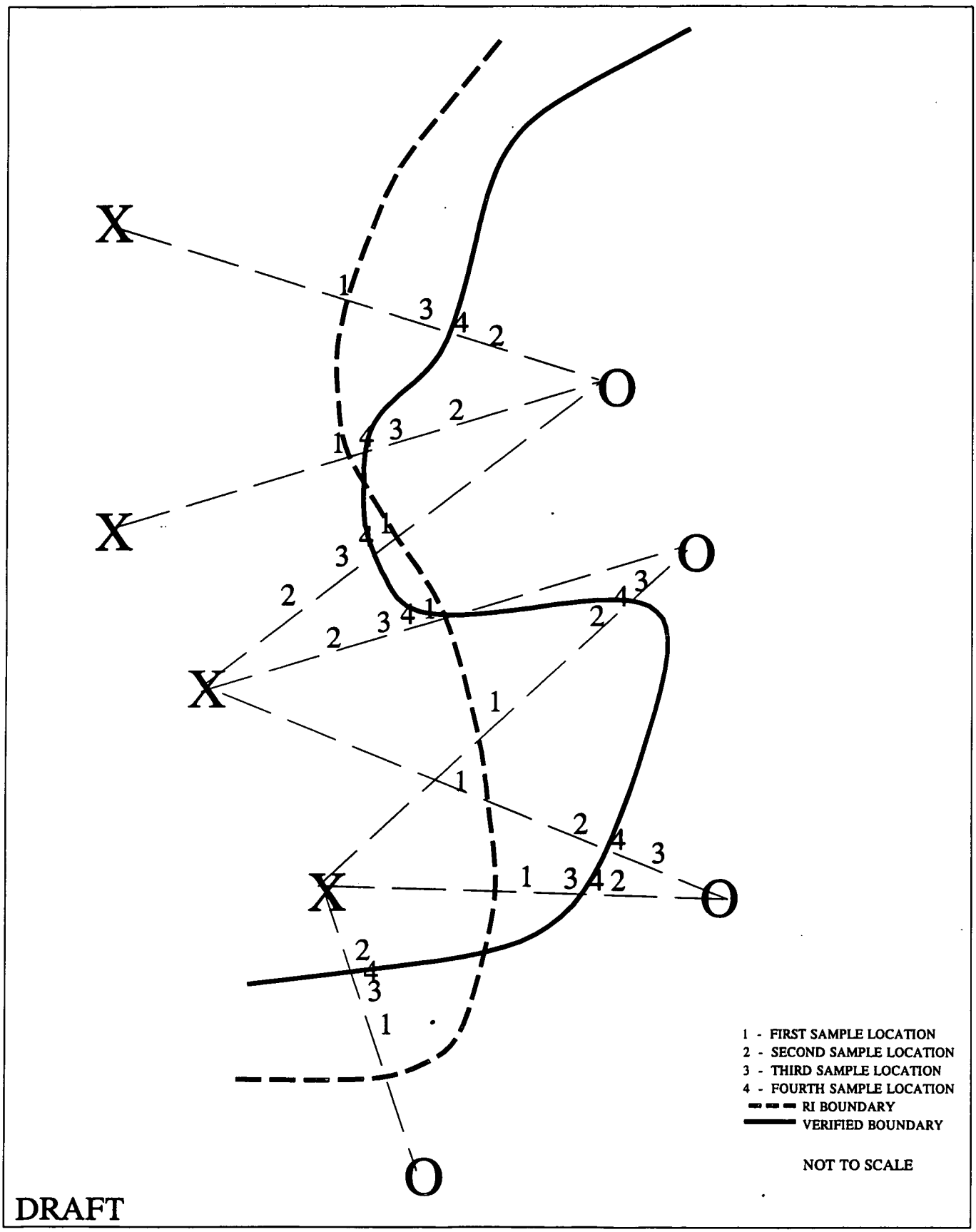

FIGURE L.1-2. SAMPLING SEQUENCE

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approximately a circle 530 feet in diameter; therefore, the sampling density would be sufficient to indicate the presence of contamination in a 5-acre area.

Sampling would continue until the boundaries were adequately defined to facilitate the mobilization and direction of excavation equipment. Random sampling would be conducted within the bounded area to verify that the assumption of contiguous contamination was appropriate. Additionally, within the bounded area, sampling would be conducted on tilled agricultural land to ensure that the surface soil continued to exhibit the elevated concentrations of uranium. For purposes of the FS, it was assumed that all collected samples would be analyzed for isotopic uranium, with a percentage sampled for other site-related COCs.

The same procedure would be used to refine the size of suspect areas. Because the available data defining these suspect areas is extremely limited, initial samples would be collected from locations within 50 feet of the RI data set. Following confirmation, the available data would be used as the basis for the design of a sampling scheme. It is conceivable that some suspect areas may be reduced in size to below the 5-acre limit and therefore not require remediation.

A similar sampling scheme would be adopted to define the area of excavation at the 10^{-5} residual risk level to the resident farmer of approximately 15 ppm. At this concentration range, some reliance can be placed on the use of total uranium analysis as opposed to isotopic analysis. Total uranium analysis offers advantages regarding both cost and turnaround time. For the FS, it is assumed that all samples collected are analyzed for total uranium with 20 percent analyzed for isotopic uranium and other potential site-introduced COCs. Associated with the verification survey at this PRL, a scan would be performed of the potentially impacted areas with hand-held radiological instruments to provide a higher degree of confidence that potential hot spots exceeding 50 ppm of uranium were detected and removed.

At a PRL of approximately 50 ppm uranium or higher, the off-property verification survey would heavily rely upon the use of hand-held radiological instrumentation. A scan survey would be conducted in all areas suspected of exceeding this level.
All or the most significant portion of soil above the action level is removed as part of the Sewage Treatment Plant Removal Action; the verification survey would reconfirm these results through the scan survey and the collection of discrete samples in areas suspected of exceeding the PRL.

Within the off-property area are three general land use types that impact sampling. These are cultivated agricultural land, rolling pastures or grass-covered areas around residences, and steep slopes with forest cover. The selection of the actual sampling locations would use the following guide for these areas. Sampling would be biased toward undisturbed areas along the edge of cultivated land

if such areas are present within 100 feet of the prescribed sampling location. If an undisturbed area is not available, samples would be collected in the cultivated area over the 0- to 2-inch interval and over the 10- to 12-inch interval to determine if uranium has been worked into the soil by cultivation activities. Grass-covered areas would be sampled at the prescribed locations. In areas with steep slopes and forest cover, samples would be collected at the base of slopes within 100 feet of the prescribed sampling location. The base of the slope is where particulates falling on the surface would accumulate due to surface water runoff.

Because the source of contamination is airborne deposition of relatively insoluble uranium, two samples would be collected at each location. A surface sample collected over a vertical interval of 0 to 2 inches and a deeper sample collected over the interval of 6 to 8 inches. It is assumed that within the lateral boundary 6 inches of soil would be removed from all areas. Certification sampling would be conducted to ensure that all contamination has been removed; therefore, verification sampling to determine the depth of contamination within the 11 square miles would not be required.

Sediment

Available data from the RI and other site sampling programs for the concentration of contaminants in the sediment in Paddys Run and the Great Miami River is limited. The ability to collect representative samples is obviously hindered by the continuously changing nature of the sediment. To verify that no excavations or dredging would be required, verification sampling would be performed in the sediment in both the creek and the river. Verification sampling is assumed to take place near the end of the soil remediation process so that any impacts of the cleanup can be addressed.

Miscellaneous Off-Property Areas

Verification sampling would not be conducted to establish the need for soil excavation at the location of the contaminated rubble and soil at the outfall line to the Great Miami River, and for the soil beneath the retired outfall pipeline along its course from the FEMP sewage plant to the river. For both of these situations, the nature or location of the potentially contaminated soil precludes the ability to perform verification sampling in advance of excavation operations. Therefore, it is assumed that any required verifications surveys would be conducted during excavation at these locations. For the contaminated rubble and soil at the outfall line, sampling performed during the RI was inconclusive due to the inability to acquire sufficient representative samples. Sampling in this area was limited due to the presence of buried concrete which prevented the collection of soil samples at depth. Available data indicate that quantities of contaminated concrete rubble and soil are located adjacent to the outfall discharge point. All remedial alternatives assume that this material will be excavated and that contaminated rubble and any soil exceeding final remediation levels would be returned to the FEMP for disposition in accordance with the ROD.

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For purposes of the FS, it was assumed that up to 12 inches of soil in a three foot wide strip along the entire length of the outfall line would require excavation to attain final remediation levels. Sampling of these soils is hindered by the presence of the buried cast iron line. Sampling is assumed to be conducted during the process of removing the line. Soil exceeding the PRLs would be returned to the FEMP for disposition in accordance with the ROD.

Off-property Access

To conduct the verification sampling program for off-property affected areas, written access agreements will be required from each involved land owner. Such agreements are presently used by the FEMP to collect environmental samples as part of the Environmental Monitoring Program. Typically agreements are readily obtained; however, obtaining access in select cases may prove difficult due to the owner's reluctance to have the property disturbed, or due to concerns over the language of the agreement. In these cases, every effort would be made to obtain access through discussions with the involved property owner. In cases where voluntary access cannot be acquired through use of the referenced agreement process, the U.S. Department of Energy (DOE) would refer the matter to the U.S. Department of Justice to exercise DOE's authorities to acquire access pursuant to Section 104(e) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

L.1.1.2 Areas Outside the Production and Waste Storage Areas Verification Survey

Surface soil contamination has been detected in the pastures and wooded areas of the FEMP outside the production and waste storage areas. Except for the trap range, the source of contamination is due to airborne deposition of constituents on the surface. Within the trap range area the source of contamination is lead shot and clay pigeon fragments deposited on the land surface coupled with airborne deposition of historical emissions from process stacks. Contamination in these areas outside other operable units is likely to be within 12 inches of the surface and a deep subsurface sampling program is not required.

The RI samples in these areas are generally too widely spaced for the development of specific excavation plans. Additional sampling is required to define the outer boundary and the vertical extent of the contamination. For the purpose of the FS, the conceptual sampling plan in these areas would be conducted on a 400-foot grid. Initial sampling locations would be based on the isoconcentration boundaries of contamination defined in the RI Report. The initial samples would be collected at the grid intersections that appear to bracket the isoconcentration boundaries. If contamination is found at both grid locations, the next location away from the isoconcentration line would be sampled. If the samples at two grid locations bracket the PRL level, samples will be collected along the grid and diagonals half way back toward the contaminated area. Based on the results of the second sample the

distance would be split a second time and a third sample would be collected to bracket the isoconcentration boundary within a 100-foot interval.

Samples will be collected at each location over depth intervals of 0 to 2, 4 to 6, 10 to 12, and 18 to 20 inches using hand tools. The top two intervals would be analyzed and the lower two intervals would be archived for later analysis if required. Both deeper samples would be analyzed if the 4- to 6-inch interval is above the PRL level.

As discussed for off-site soil, the method of detection and analytical procedures will be determined by the PRL defined in the ROD. Hand-held instruments would be used to the extent practical for the verification sampling program. Hand-held instruments may be used in the initial sampling to determine if the soil is grossly contaminated. If so, the field instrument result would be used and additional samples would be collected at the next grid away from the contaminated area. If PRL levels allow hand-held detection instruments to be used for defining the extent of contamination, 20 percent of the samples defining the clean area would be sent to a laboratory for confirmatory analysis.

L.1.1.3 Areas Within the Production and Waste Storage Areas Verification Survey

It is assumed for the development of verification sampling that the majority of the buildings would be removed from the production area and that only residual soil would be present from the waste pits and other operable unit areas.

Soil

Sampling would be conducted using the same logic as presented in Section L.1.1.2; however, the grid size would vary depending on the area and contaminant present. Because sources of contamination in these areas include spills and liquid leaks, sampling would extend to the water table or to a depth 5 feet below the depth of the RI sample that indicated contamination was present. Sampling would begin with the 6-inch interval used by the RI samples and continue with 6-inch samples collected every other 6 inches until the bottom of the boring is reached.

Hazardous Waste Management Units

In the FS, estimates were made of the volume of soil containing both listed and hazardous wastes at levels requiring action in the vicinity of hazardous waste management units (HWMUs) to be closed in conjunction with remedial activities and for other localized areas of soil at the site. Additionally, the volume of soil potentially containing petroleum products due to releases from underground storage tanks was estimated. Verification sampling around HWMUs and underground tanks would be done beginning with a 100-foot grid. After the sampling interval is split twice the boundary would be

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bracketed laterally within a 25-foot interval and vertically within a 6-inch interval. Three-dimensional sampling plans could be generated from this data.

Hand-held detection instruments would be used where applicable to reduce the cost and time required to conduct the verification sampling. In addition to radiological detectors, photoionization detectors, portable volatile organic analyzers, and portable x-ray fluorescence equipment would be employed to screen samples when appropriate, based on PRL levels.

Perched Groundwater

Where perched groundwater is contaminated the soil containing the perched groundwater would be excavated. It is therefore necessary to determine the extent of the coarse-grained sand and silt that contain the perched groundwater and the depth to the base of these geologic units. For the FS, the coarse-grained material would be removed if it is capable of a sustained yield of 1 gallon per minute (gpm) for at least two days. The outline of the coarse-grained material to be removed has been presented in Section 2.0 of the FS and the strategy for cleanup is presented in Section 4.0.

Groundwater sampling records would be reviewed to determine which wells and existing piezometers, near the edge of the perched groundwater contamination zone would be tested for yield. Low volume peristaltic pumps would be used with a flow meter to determine the yield of each well or piezometer. Wells or piezometers that typically went dry during sampling would be assumed to be below the 1 gpm yield criteria.

The production area has been sampled geologically on a 250-foot grid. The conceptual approach for the FS would be to drill and sample for geologic information around the perched groundwater contamination areas using the existing 250-foot grid or an extension of it. Borings would be advanced to determine the subsurface geology and if perched groundwater is available from the sediment. Samples would be collected with an appropriate sampling device to provide a full geologic description of the material in the subsurface. The boring would advance until at least 3 feet of till has been penetrated below the water-bearing unit or the boring is within 5 feet of the base of the glacial overburden, whichever comes first. Because the sampling is to provide a definition of the water-bearing unit there is no need to collect samples for chemical analyses. If the boring has at least 2 feet of free water during drilling and if there are no piezometers within 125 feet of the boring, a piezometer would be installed in the boring; otherwise, the boring would be backfilled with grout. A yield test would be conducted and water levels would be monitored during excavation to verify that the water levels fall as excavation proceeds and the correct unit is being excavated. Post-excavation certification samples would be taken after the perched groundwater zones are removed to ensure that the contamination has been removed.

Soil in Storage

For soil currently in storage piles and boxes, the volume estimates were made on the basis of available data, process knowledge, or best engineering judgment. Before the initiation of detailed design of treatment systems to address the petroleum products or the RCRA-regulated components of the soil, characterization would be completed by sampling the storage piles and boxes to the extent necessary to provide a more refined estimate of the affected soil volumes.

L.1.2 EXCAVATION

Soil, sediment, and gravel exceeding the PRLs would be excavated using conventional earth-moving equipment, including backhoes, track or skid loaders, etc. Conventional earth-moving procedures would be modified to minimize both the excavation of clean (i.e., below the PRLs) materials and the generation of fugitive dust.

During the mobilization stage, air monitoring stations would be established at the perimeter of the excavation, as required, to be used in conjunction with other environmental and personnel monitoring (i.e., surface water monitoring, lapel monitoring, etc.) to determine the potential releases of airborne or waterborne contaminants from the excavation site. This monitoring network would be used to evaluate the performance of any mitigative measures employed during the excavation process to minimize releases to the environment. Before initiating excavation at a given area of the site, a set of baseline monitoring data would be collected to serve as a basis for trending analysis. Air and surface water samples would be collected and submitted to an on-property laboratory (i.e., existing FEMP laboratory or a trailer-based system) for more expedient analysis.

As part of site preparation and mobilization, required documentation, including task-specific health and safety plans, a storm water management plan, and an erosion and sediment control plan, would be prepared to support field operations. During the site preparation phase, necessary vertical and horizontal controls would be established to support construction-related surveying. Ground surveying techniques would serve as the basis for locating required facilities, establishing sampling grids, identifying certification sampling coordinates, estimating quantities of excavation and backfill material, and supporting the development of as-built drawings.

As previously discussed, the excavation of contaminated soil, sediment, and gravel must be effectively coordinated with remedial actions at each of the operable units. Significant quantities of soil requiring excavation are located under or adjacent to existing structures, pipelines, pits, silos, and landfills located on the FEMP property. Additionally, certain remedial alternatives would require the excavation of soil from off-property locations. A preliminary level of detail on the sequencing of the excavation process is provided below. A more thorough examination of the sequencing of remedial actions would be conducted following remedy selection, during the remedial design process.

L.1.2.1 Off-Property Excavation

Following verification of the vertical and horizontal extent of contamination requiring excavation from off-property locations, the FEMP would pursue the establishment of remedial action agreements with each of the affected property owners. Similar agreements have been used effectively for other large scale DOE cleanup programs. These agreements typically inform the property owners of the type and extent of contamination residing on their property and the planned actions to remove the materials. The agreement would also document the required actions to be conducted by the DOE to restore their properties to its preexisting condition. Copies of such agreements are typically provided to any tenants residing on the affected land. DOE has been very successful in obtaining such agreements with involved property owners, but the process is complicated by establishing true land ownership or contacting nonlocal owners. Where access cannot be acquired following good faith efforts by the DOE, the matter would be referred to the U.S. Department of Justice to acquire access pursuant to the previously discussed authorities granted to DOE under CERCLA.

After access is obtained, involved areas would be strategically segmented to provide for an orderly performance of remedial activities. Before beginning, any required environmental monitoring stations would be established and natural and cultural resources plans would be developed. In general, excavations would be initiated at the point farthest from the FEMP and progress toward the FEMP. Excavation equipment would be selected based on site conditions. The size of such equipment is typically limited by access constraints present at the property and the desire not to damage adjoining structures or improvements.

Soil would be excavated to the extent necessary to remove contaminants to a condition which is statistically less than the cleanup standard (i.e., the PRL). Available statistical techniques and hot spot criteria would be employed to successfully attain the PRLs while minimizing the need to remove trees, shrubs, pavement, pools, etc. Excavated soil would be loaded directly onto dump trucks, covered, and transported to the FEMP property. Appropriate controls would be employed, including the use of water sprays to minimize the generation of fugitive dust during excavation. The use of controls for storm water management is not envisioned as being required for most affected off-property areas due to the low average contaminant concentrations. The determination of the specific mitigative measures required to facilitate off-property excavations would be determined during remedial design.

L.1.2.2 On-Property Excavation

Acquiring access to contaminated soil located underneath or immediately adjacent to processing facilities, support buildings, pads, and pavement within the former production area is dependent upon the completion of decontamination and dismantlement activities under the Operable Unit 3 interim remedial action and final remedial actions. The completion of these remedial activities would be

completed in an integrated manner over approximately 16 years. Final remedial schedules for dismantlement would be established through the Remedial Action Work Plan for Operable Unit 3 and are highly dependent on available disposal capacity and funding.

The FEMP contemplates removal of above-grade facilities, equipment, piping, and tanks within the former production area on a segmented basis. After a given segment (i.e., quadrant) is cleared of above-grade facilities, leaving cleaned (i.e., scabbled, steam washed) foundations, pads, and roadways, the area would be released for an integrated excavation process involving the removal of surface pavement and foundations in conjunction with below-grade improvements and contaminated soil.

There is a large quantity of gravel on the roadways and beneath the building pads and foundations in the production area; a large section north of Second Street is covered with an average of 1.5 feet of gravel between the buildings. In most cases this gravel overlays contaminated soil and is itself contaminated to levels exceeding the PRLs. Gravel would be excavated along with the soil and disposed of in accordance with its radiological contamination.

The integrated pavement/foundation removal and soil/gravel excavation process would start in the northeast sector of the former production area and proceed in a western and southern direction. The specific sequence would be established as part of the Operable Unit 3 interim remedial action and final remedial design process. Considerations in this final sequencing would include: 1) minimizing the potential for storm water run-on to previously excavated and certified areas; 2) maintaining needed plant infrastructure, including power, heat, water, storm sewers, and sanitary sewage collection and treatment to the extent practical to support the remediation effort; and 3) maintaining strategic storage, treatment, and other facilities required to support the remediation effort.

Following completion of necessary health and safety and radiological protection surveys, establishment of radiological control areas and monitoring networks, identification and lockout of underground utilities, and flushing of underground lines, the remaining concrete and asphalt pavement and building foundations would be scored/saw cut, as necessary, and broken with a concrete buster. Broken concrete would be segregated from underlying soil, to the extent possible, and loaded by a backhoe into 40-ton roll-off containers for disposition in accordance with the selected remedy for Operable Unit 3. Appropriate mitigative measures, including the use of water sprayers and/or foggers, would be implemented during the concrete breaking and loading process to preclude the generation of fugitive dust.

Following removal of the pavement and foundations, soil and gravel excavation would proceed, typically using a backhoe. The areal extent of open excavation (i.e., area undergoing excavation

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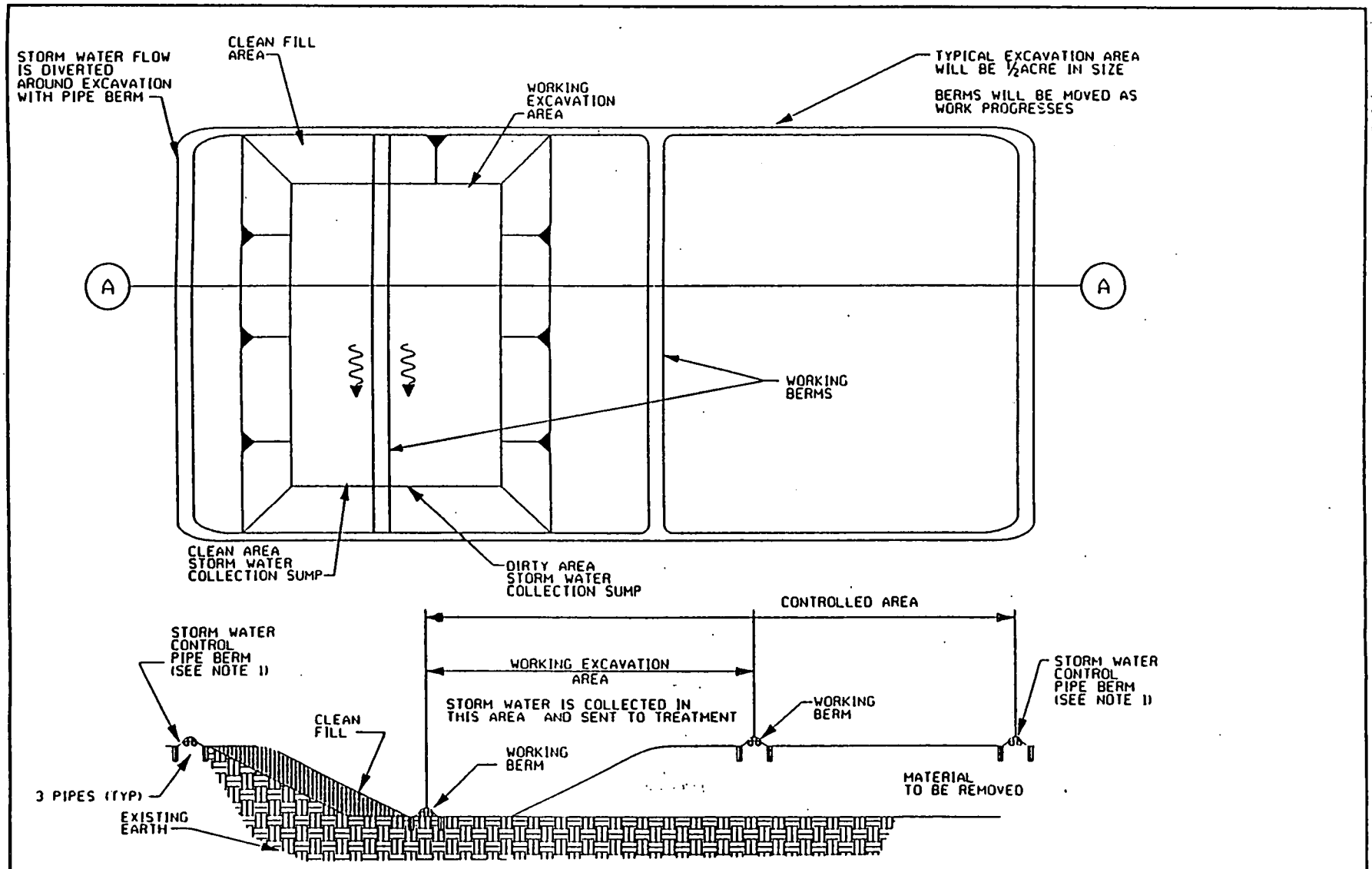
before certification) would be limited to the extent practical to preclude potential fugitive releases and cross contamination. To preclude potential soil contamination migration into adjoining areas, into previously cleaned areas, or deeper into the soil column, appropriate control measures would be taken during the excavation process, including:

- Positioning backhoes, etc., and receiving trucks or containers on existing paved areas, clean haul roads, or temporary plank roads to the extent practical
- Minimizing the use of tracked vehicles in contaminated areas to preclude affected soil being forced lower into the soil column
- Removing the teeth from backhoes, buckets etc., or welding a cover plate over the teeth to eliminate contaminated soil being pushed progressively deeper during excavation
- Using water sprays, foggers, etc., to preclude fugitive dust emission
- Maintaining adequate storm water controls during excavation, potentially including temporary dikes (i.e., pipe beams), to collect run-on water and perched groundwater and direct it to tankage or nearby sewer systems, as appropriate.

Areas which indicate the presence of contaminant concentrations exceeding PRLs would be excavated. A typical excavation cross section is presented in Figure L.1-3. Consistent with the conceptualization of the excavation process presented in Figure L.1-3, approximately 0.5-acre areas are envisioned to be undergoing active excavation at any one time. Limiting the areas of active cleanup is necessary to minimize the need for the handling of collected storm water. The need to use multiple excavation sites would be determined during remedial design and remedial action.

As indicated in Figure L.1-3, appropriate storm water control measures would be provided during excavation. In areas of deeper excavations exceeding approximately 6 to 8 feet, quantities of perched groundwater are expected to enter the excavation. The quantities of groundwater encountered at the excavation site are highly dependent on the localized geologic conditions. As previously discussed, collected perched groundwater would be pumped from the excavation to tankage or a nearby site sewer system, as appropriate. It is envisioned that in areas of perched groundwater exceeding maximum concentration levels (MCLs) or proposed MCLs, perched groundwater (including any collected storm water) collected in the excavation would be pretreated, transferred to tankage and then transported to the advanced wastewater treatment (AWWT) facility for supplemental treatment.

It is anticipated that soil excavated from perched groundwater zones would have high moisture content and would require special consideration for handling. This soil would be excavated and aerated for ease of handling. Soil would be spread out over a large area and allowed to dry out before loading in



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NOTE:

1. CONSISTS OF 3-12" ø HDPE PIPES AND A 45 mil GEOMEMBRANE ANCHORED IN 4" x 24" TRENCH SLOTS

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roll-off containers for disposition in accordance with their radiological contamination. Storm water runoff and groundwater drained from this soil during aeration would be collected by temporary storm water collection berms, transferred to tankage, and transported to the AWWT facility for treatment. As indicated in Section 4.1, perched groundwater collected in the vicinity of the fire training area and the sewage treatment plant (both facilities are Resource conservation and Recovery Act (RCRA)-listed organic waste HWMUs) would be pretreated for listed organic constituents before delivery to the AWWT facility. Drinking water MCLs (or 10^{-5} concentrations for constituents without MCLs) for the RCRA-listed constituents would be used as the action level to designate when pretreatment of collected perched groundwater from these two areas is required. The pretreatment step is necessary to avoid contaminating other AWWT treatment residuals with RCRA listed constituents.

Underground pipelines encountered during the soil excavation process would be segmented from the surrounding soil to the extent possible and cut into manageable sections. The piping would be loaded into 40-ton roll-off containers, with the ends wrapped to preclude any releases during transport. Filled roll-off containers would be transferred to the appropriate staging area for disposition in accordance with the selected remedy for Operable Unit 3.

Contaminated soil would be segregated to the extent possible based on contaminant concentrations at the time of excavation in support of the particular requirements of the selected remedial alternative. This segregation process would be conducted through a combination of the results of the verification surveys and excavation control surveys. Maintaining sufficient controls during the excavation process is key to minimizing the removal of underlying or adjacent clean soil (i.e., less than the PRL), while at the same time providing for continuity and efficiency in the excavation process.

In general, excavation would proceed over the area and depth established by the inclusion and verification surveys. Digging would proceed to the planned extent and interim measurements or sampling are not anticipated.

When excavation has proceeded to the expected boundaries, consistent with the PRLs, measurements would be taken with hand-held radiological detection instruments. Multiple measurements would be taken over each 10-meter grid (100 m^2 area). If instrument measurements are clearly elevated and in excess of the PRL values, further excavation is indicated. If instrument measurements are adequate to monitor PRL levels, the concentrations would be averaged and compared to the PRLs. If any individual measurement exceeds three times the PRLs, that area would be further excavated. Where elevated activity is less than three times the PRL, results would be assessed to assure that the median concentration is less than the PRLs.

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When instrument measurements lack the requisite sensitivity, four samples would be collected from each 100 m^2 grid for screening-level analysis at an on-property laboratory. Analysis would be conducted for contaminants such as uranium, that are anticipated to be laterally extensive and are conducive to screening-level analysis. The method to evaluate the concentrations would be identical to that used for instrument measurements for average and elevated activity.

For certain contaminants, such as technetium-99 and radium-226, it may not be possible to achieve the analytical sensitivity in the screening lab that is required to meet the PRLs at the lowest risk levels for the most sensitive land uses. The relative concentrations among the contaminants may obviate this problem; uranium isotopes predominate and analytical sensitivities are adequate to meet the most restrictive PRLs for uranium-238 and uranium-234.

Delays would be incurred to the excavation process for receipt of analytical results. The area would not be backfilled, but adequate controls and mitigation would enssure that any remaining contamination would not become airborne and that potential surface water transport would be controlled.

Soil suspected of containing RCRA hazardous waste constituents above waste acceptance criteria for the RCRA COCs (for on-site alternatives), above (TCLP) limits (for off-site alternatives), or originating directly below acontaining HWMU listed waste (for off-site alternatives) would be segregated and containerized into separate roll-off containers and transferred to the central storage facility or another existing facility appropriate for the storage of land disposal restricted (LDR) materials. Additionally, soil containing significant concentrations of benzene, toluene, ethyl benzene, and xylene generated during underground storage tank removal would be segregated during the excavation process. The pretreatment of these segregated soil volumes is discussed later in this component description. A full discussion of the LDR compliance strategy for Operable Unit 5 materials can be found in Section 4.0.

While efforts would be made during excavation to minimize the removal of trees, shrubs, and other vegetation, quantities of these organic materials would be removed to gain access to contaminated soil or to attain PRLs. Trees and shrubs requiring excavation within contaminated areas would be cut off at the ground level, with the above-grade portion surveyed and released from the site for use as firewood, composting, or landfilling. Trees, shrubs, vegetation, and root systems which cannot be released as clean would be segregated during excavation.

Contaminated organic materials (i.e., roots, stumps, etc.,) would be shredded, composted, mixed with soil and placed in the on-property disposal cell or consolidation area. Catalysts may be used to accelerate the composting process. However, care would be taken in the selection of the composting

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catalysts to preclude the possibility of exceeding waste acceptance criteria (WACs) for the disposal cell/consolidation area. A test pad would be constructed to study the composting process as well as to establish the soil-to-compost ratio for placement in the on-property disposal cell or consolidation area.

Any soil underlying or adjacent to Operable Units 1, 2, and 4 waste facilities requiring removal as part of the selected alternative for Operable Unit 5 and the respective source operable unit would be excavated in conjunction with the implementation of the remedy for the individual waste unit. Modeling projections of the extent of contamination underlying these facilities suggest that quantities of soil would require excavation to attain PRLs for certain Operable Unit 5 alternatives. Additionally, surface and subsurface soil sampling completed as part of the Operable Unit 5 RI to support the Operable Unit 4 RI/FS indicates that soil comprising the berm and underlying the silos would require excavation to attain site-wide soil PRLs. Soil within the K-65 silo berms and underlying the pits and silos that exceed the PRLs would be excavated, as necessary, during the implementation of any selected remedy for Operable Units 1 and 4 which involves source removal. Removed soil would be segregated, as necessary, to support the selected Operable Unit 5 remedy and placed into roll-off containers.

In the former production area, soil exceeding PRLs and requiring excavation may reside underneath clean soil. Under these circumstances, the clean soil would be removed and stockpiled in the vicinity of the excavation to gain access to the underlying contaminated material. Stockpiled materials would not be returned to the excavation as backfill until after completion of the certification process.

L.1.3 TRANSPORTATION

Loaded trucks or roll-off containers would be covered with tarps and transported to their on-property destination. This destination is dependent on the selected remedial alternative and is discussed in other components. Roll-off containers would be picked up by roll-off container trucks. Spare containers would be positioned at the excavation site to minimize cycle time delays.

Loaded trucks would be radiologically screened, as required, before exiting the controlled area encompassing the excavation site. Trucks exceeding allowable release limits would be directed to a wheel wash station. As previously discussed, containers and trucks would remain off the contaminated soil to the extent practical to preclude the need for cycle time delays due to wheel washing. Truck cycle times are anticipated to be from 60 to 75 minutes dependent on the need for radiological screening and wheel washing. This process would continue for one eight-hour shift per day for five days per week. For the purposes of this study, the excavation cost estimates are based upon four trucks being filled per hour per excavation site, or 160 tons per hour. Higher excavation and material movement rates can be easily accommodated through the addition of equipment, if areas cleared of buildings and/or treatment/disposal capacity become available.

L.1.4 CERTIFICATION OF EXCAVATED AREA

Following completion of excavation operations, including any required hot spot removal, final certification would be conducted to demonstrate attainment of the final cleanup levels. Final certification sampling would be conducted to indicate with reasonable confidence that the area's average contaminant concentrations are statistically above the cleanup standards established in the ROD. The final certification sampling would be conducted using a statistical basis consistent with the EPA technical memorandum entitled "Methods for Evaluating the Attainment of Cleanup Standards." The final certification approach adopted for use at the FEMP would be established in the Operable Unit 5 Remedial Action Work Plan, consistent with the Amended Consent Agreement. To establish a basis for alternative cost analysis in the FS, a certification methodology was adopted.

Consistent with the referenced EPA guidance document, a systematic certification sampling approach was adopted. Excavated areas would be gridded to 100 m^2 areas. Four randomly determined survey locations would be established within each ten-meter by ten-meter grid. Measurements would be made and samples collected at each survey location. The RI data show that the principal contaminants are uranium isotopes. Unless otherwise indicated, 90 percent of the certification samples would be analyzed for uranium isotopes and 10 percent for the full list of contaminants. A percentage of samples are assumed to be split for comparative analyses by the EPA and Ohio EPA (OEPA).

To determine whether a discrete 100 m^2 area attains cleanup levels, a statistical comparison of the one-sided upper confidence interval on the mean of the data collected from each grid with the cleanup levels for uranium (and for larger surface areas for other COCs) would be performed. Other considerations in this statistical process are provided in the referenced EPA guidance document, Chapter 6, "Determining Whether the Mean Concentration of the Site is Less than a Cleanup Standard." If a value is reported by the analytical laboratory to be less than the detection limit, the value included in the analysis would be assumed to be the detection limit. Areas where individual sample contaminant concentrations exceed three times the PRLs would be considered for further evaluation to determine if the sample represents a "hot spot" to be excavated or is indicative of a larger area of contamination which would need to be reevaluated.

Following consensus that the cleanup levels had been attained over a sufficiently large parcel of land, backfill operations would commence. Further discussions on this activity can be found in the description of the backfill component.

L.1.5 TREATMENT OF SOIL AND WATER CONTAINING HAZARDOUS WASTE, PETROLEUM, AND POLYCHLORINATED BIPHENYL CONTAMINATION

Relatively small volumes (less than 30,000 cubic yards) of in situ soil containing hazardous wastes, petroleum, and polychlorinated biphenyls (PCBs) are present at the FEMP in concentrations exceeding WACs for on- or off-site disposal. On the basis of available site characterization data, it is anticipated that all soil containing these contaminants will also contain above-PRL concentrations of uranium. Because of the relatively small volume of soil involved pre-treatment would be accomplished with mobile, vendor-supplied treatment units before final soil disposition. At a minimum, soil would be treated to reduce hazardous waste contaminant concentrations to levels below WACs (for on-site alternatives) or LDR treatment standards (for off-site alternatives). Section 4.1 provides the details of the LDR compliance strategy adopted for the Operable Unit 5 FS.

Two technologies have been chosen for treatment of this soil, low temperature thermal desorption and soil stabilization; both were listed as treatment technologies in the proposed rule for treatment of soil containing RCRA hazardous waste (58 FR 48153). Thermal desorption was chosen based upon treatment information available on the EPA's Vendor Information System for Innovative Treatment Technologies (VISITT) database. Figure L.1-4 presents the logic flow diagram for the disposition of soil containing nonradioactive contaminants.

Soil containing organic contaminants (e.g., petroleum, PCBs, and volatile and semivolatile organic compounds) would be treated using low temperature thermal desorption. A flow diagram for this process is provided as Figure L.1-5. During treatment, contaminated soil is fed into a rotary kiln to volatilize organic contaminants. The kiln can be directly or indirectly heated to about 800 degrees F. Indirect heating produces a lower volume of exhaust gas than direct heating, which results in a lower loading for the exhaust-gas treatment and air pollution control systems. This also aids in the control of particulate carryover. Kiln-direct heating uses either a burner exhausting directly into the kiln or hot air produced by an external direct-fired heat exchanger.

The organic contaminants would be volatilized and driven off the soil, along with vaporized water, as an off-gas. Exhaust gases from the rotating kiln pass through to secondary combustion, where the off-gas is incinerated to thermally destruct organic compounds. Remaining volatilized compounds in the off-gas can be removed by scrubbing, reheating and high effficiency particulate air (HEPA) filtration before discharge. As organic concentrations and the heating temperature are low, no combustion of the organics is anticipated in the kiln. However, a standby nitrogen system would be installed as a safety precaution to blanket the chamber in the unlikely event of a fire or high temperature.

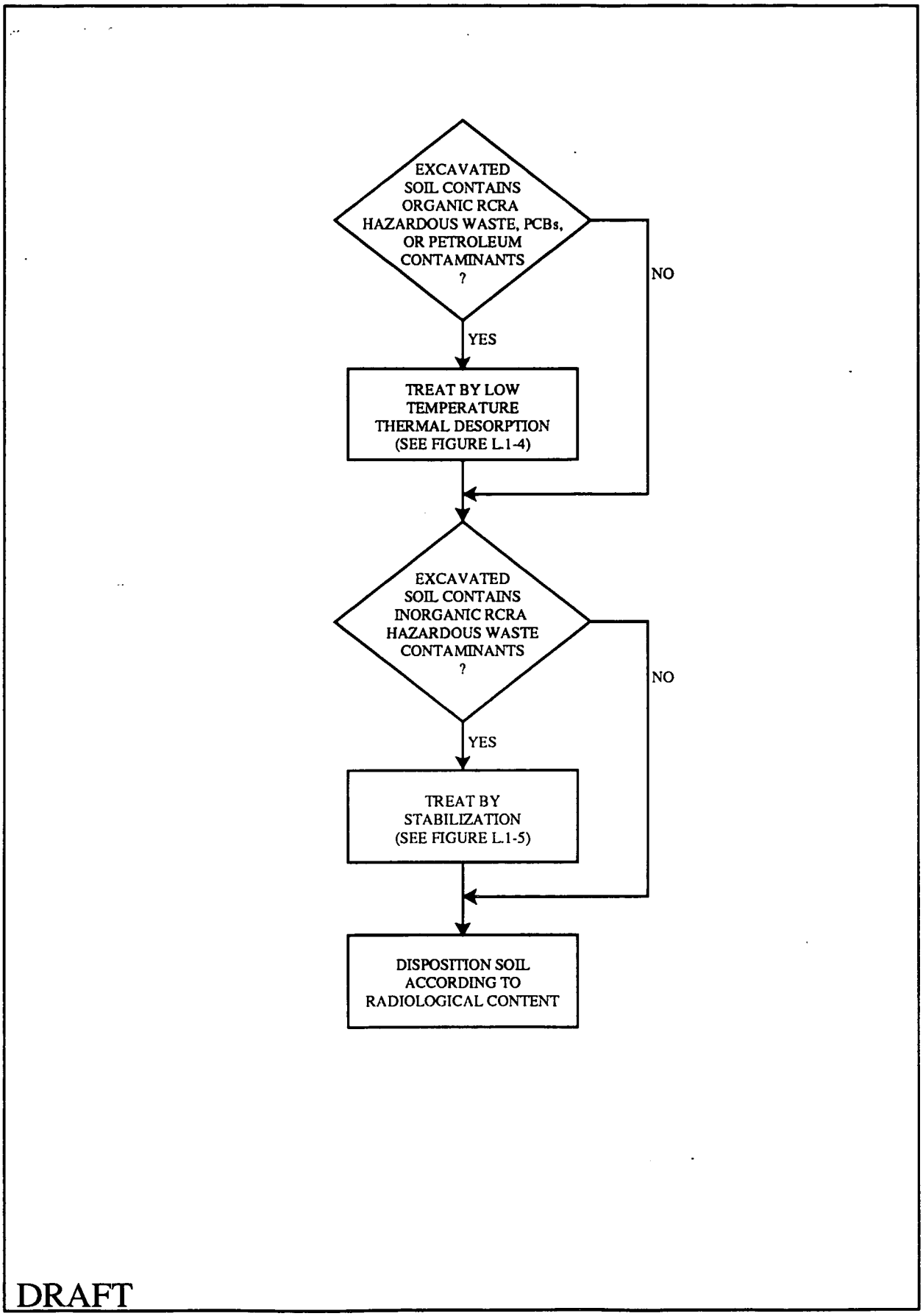

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FIGURE L.1-4(SOIL TREATMENT FLOW DIAGRAM

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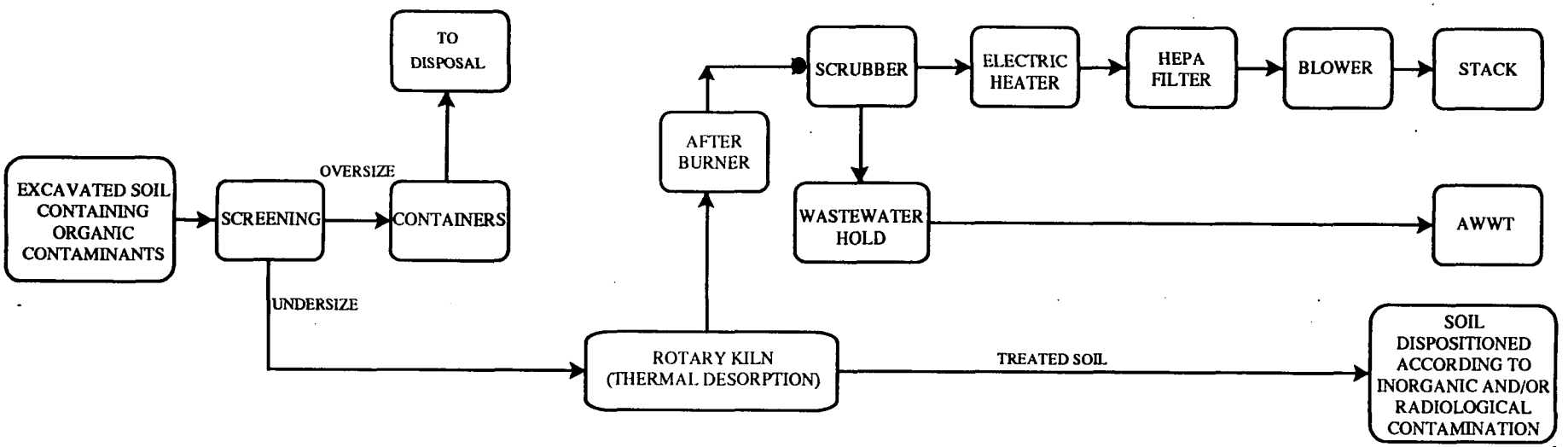

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FIGURE L.1-5. THERMAL DESORPTION PROCESS

After thermal desorption (if required), soil containing inorganic contaminants would be treated by cement stabilization. A flow diagram for this process is presented in Figure L.1-6. This process will convert soil into a matrix that prevents contaminants from leaching. The process involves mixing the soil with cement, flyash, silicates or other additives, and water. The mixture then goes through a curing process. Stabilization processes increase the volume of treated material; however, they leave no waste residues. Cement stabilization may also be used to treat soil containing organic contaminants. The combination of admixtures, as well as the feasibility of stabilizing soil containing organic contaminants, would be examined further during treatability testing. Stabilized soil would be dispositioned for disposal as no further treatment for radioactive contaminants would be required.

In general, treated soil would be dispositioned consistent with the approved method for uranium-contaminated soil identified through the selected remedial alternative. For alternatives involving the application of an on-property consolidation area or an engineered disposal cell, the treated soil would be placed in these systems. For alternatives considering off-site disposal as a primary component of the remedy, soil containing listed waste resulting from excavation operations adjacent to HWMUs would be dispositioned off-site as mixed wastes following treatment.

Water collected in the excavation suspected of containing listed hazardous wastes (i.e, from contact with contaminated soil or impacted groundwater) would be segregated for treatment. This situation is anticipated to remove only listed organic constituents. The affected water would be treated using activated carbon filters available at the AWWT.

The FEMP is pursuing compliance with the terms of the Federal Facilities Compliance Act regarding the development of treatment capabilities to address inventoried LDR mixed wastes. A Site Treatment Plan is scheduled to be submitted to EPA and OEPA in the spring of 1995 proposing a plan and schedule for developing the necessary treatment capacities to address these currently inventoried wastes. The proposed treatment systems developed pursuant to this federal regulation could potentially be used to address the projected type and quantities of soil containing both organic and inorganic hazardous waste constituents generated consequential to remedial actions. In the event such systems are available at the FEMP, these systems would be used preferentially to meet WACs in lieu of procuring new or vendor-supplied capabilities.

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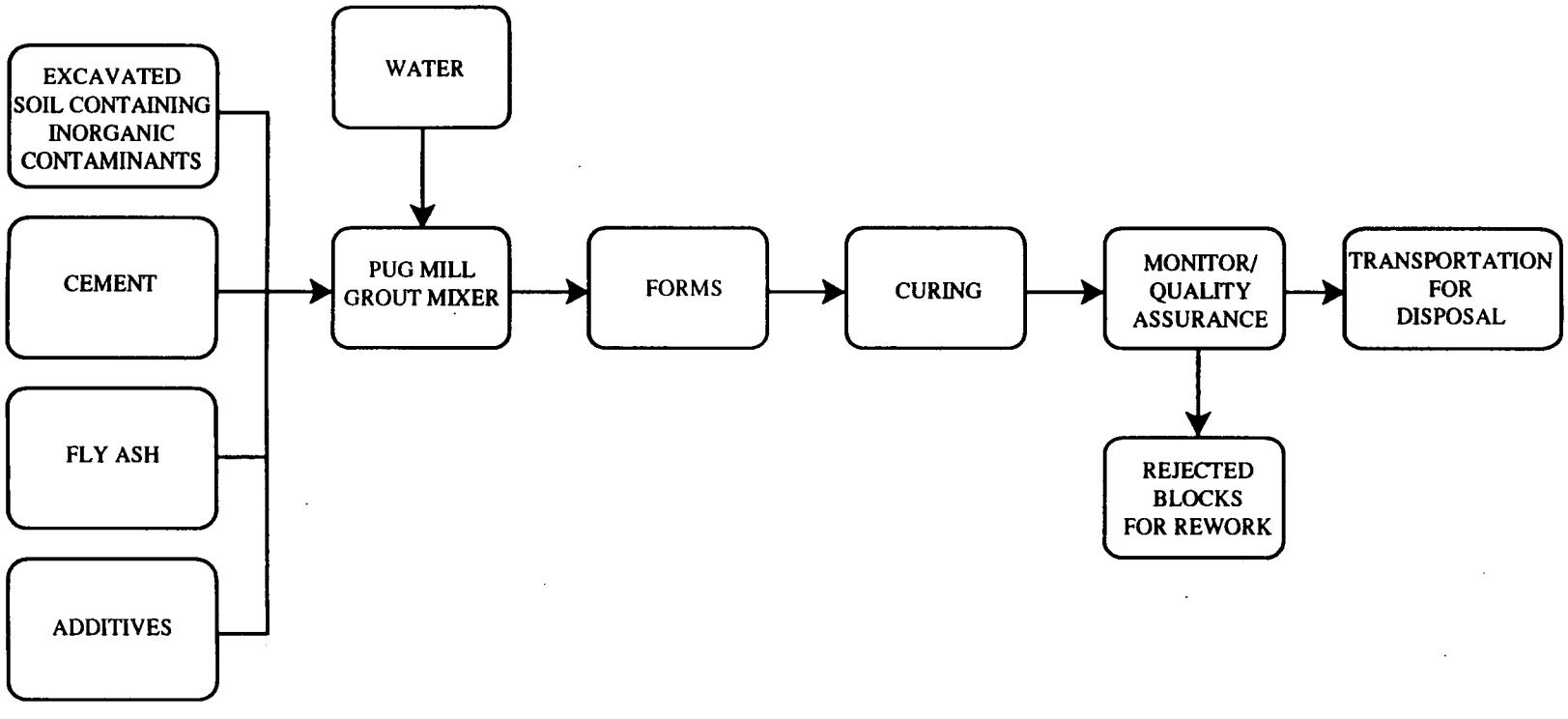

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FIGURE L.1-6. STABILIZATION PROCESS

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L.2.0 SOIL WASHING

This component utilizes a combination of physical separation and chemical extraction techniques to separate uranium (the major contaminant of concern) from contaminated soil and sediment. Once processed, the resultant clean soil is consolidated or backfilled, consistent with the selected remedial alternative. Consolidated and backfilled soils would then be covered by an earthen cover. WACs have been developed for soil treated through soil washing and subsequently covered by an earthen cover. The WACs provide for protection of the Great Miami Aquifer because the earthen cover is not assumed to reduce the infiltration rate over that of native soil. In addition, consolidation and backfill under an earthen cover would preclude the potential for direct contact, incidental ingestion/inhalation, or direct radiation exposure to any residual contamination remaining on the washed soil.

The soil washing component would include seven buildings, associated concrete pad areas, an external clean soil stockpile, and associated pavements. The component buildings include:

- An incoming storage facility for contaminated soil
- A soil washing facility
- A services and utilities building
- Two filter cake buildings
- A maintenance building and spare parts storage
- Two wheel washing/radiological screening facilities.

The proposed site is located south of the AWWT facility and west of the existing storm water retention basin (SWRB) in the southwest quadrant of the FEMP site. Past site history indicates that the area was not previously used during production or for waste disposal. Site environmental monitoring samples indicate the area is relatively free of subsurface contaminants.

The proposed site was selected because the soil washing project utilities would be connected to the AWWT facility utilities. Tapping into these utilities would minimize costs. Included in the utility connections would be process water and wastewater lines between the AWWT facilities and the soil washing facility. The soil washing process would use the treated effluent from the AWWT facilities as process make-up water and return the soil washing wastewater to the AWWT for treatment.

Once all soil washing operations have been completed, the process facilities and equipment would be decontaminated and demolished.

L.2.1 DESIGN CONSIDERATIONS

The conceptual design of the representative soil washing process selected to support the detailed analysis of alternatives incorporates both carbonate leaching and sulfuric acid leaching for uranium removal. The following considerations were incorporated in the conceptual design:

- Consistently attain performance-based WACs for consolidation and backfill with an earthen cover by reducing the mass of uranium in contaminated soil and achieving mobility reduction for residual contamination on washed soil.
- Use physical separation techniques to the maximum extent practical to reduce the overall volume of material requiring chemical treatment.
- Provide for continuous carbonate leach process operations at a rate of 20 tons of contaminated soil per hour.
- Provide for continuous sulfuric acid leach process operations at a rate of 1.7 tons of contaminated soil per hour.
- Enhance the chemical leaching process through attrition scrubbing.
- Maximize the use of recycled process water.
- Provide for product inspection and quality assurance to ensure that performance requirements have been attained before disposal.
- Use engineered dust collection systems to minimize radioactive airborne particulate material within materials handling facilities.

Upon consideration of the above design requirements and of the results of the actual bench-scale and pilot-scale operations, the soil washing flow diagram depicted in Figure L.2-1 was developed as the representative design basis for the detailed analysis of alternatives.

L.2.2 PROCESS DESIGN

The following unit operations are involved in soil washing:

- Incoming material handling
- Washing, screening, flocculation and thickening
- Carbonate leaching and filtration
- Sodium hydroxide precipitation
- Sulfuric acid leaching and filtration
- Calcium hydroxide precipitation
- Reagent receipt and handling
- Waste handling
- Clean soil handling

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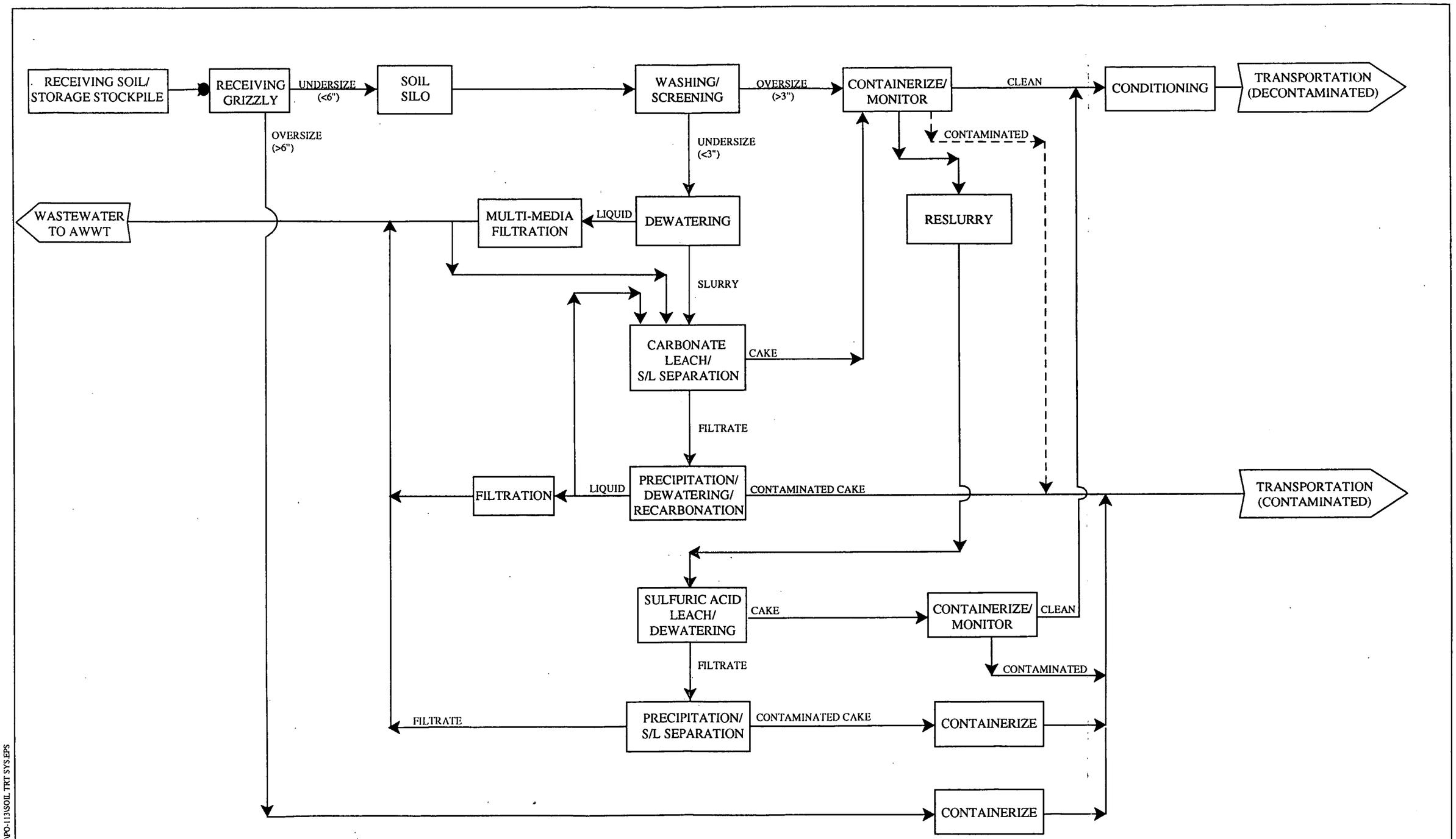

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FIGURE L.2-1 . SOIL WASHING FLOW DIAGRAM

The following sections provide detailed descriptions of the soil washing unit operations.

L.2.2.1 Incoming Material Handling

Figure L.2-2 provides a process flow diagram and a major equipment list for the incoming material handling operation. An incoming soil storage facility would provide storage for contaminated soil before treatment. The incoming soil storage facility would be divided into active and backup storage. The active storage would provide feed soil for soil washing operations. The backup storage (up to 3500 tons) would store excess soil over and above the daily process requirements and would be used to supply material to the soil washing facility during weekend operations. Excavated soil would be dumped from 40-ton roll-off containers to the backup storage pile. A track loader would move soil from backup to active storage. A hydraulic excavator would transfer soil from the active stockpile to the feeding hopper of a vibrating grizzly. Any contaminated soil size over six inches would be screened off into a container which would be transferred to a storage area for subsequent radiological monitoring and disposition. The undersize (less than six inches) material from the vibrating grizzly would be conveyed to a 50-ton capacity soil silo. A dust collection system would be integral to the soil silo to minimize escape of radioactive airborne particulate matter into the facility. The silo discharge apron feeder would direct the soil onto a 24-inch-wide belt conveyor for transfer to a vibrating grizzly in the soil washing facility. The incoming soil storage facility would be covered and equipped with stormwater control at its perimeter. It will also be equipped with a leachate collection system.

L.2.2.2 Washing, Screening, Flocculation, and Thickening

Figure L.2-3 provides a process flow design and a major equipment list for the washing, screening, flocculation and thickening operations.

Washing and screening is performed on the soil to loosen and remove any surface contamination that may be present. This process is adequate for decontaminating the soil particles greater than 4 mesh (0.157 inch) which have contaminants physically bound to them. The soil particles less than 0.157 inch have contaminants chemically bound to them, making water washing ineffective.

Soil is prescreened through a six-inch grizzly during the incoming material handling operation. Soil from the incoming soil storage facility is then fed by a feed conveyor to a vibrating bar grizzly with a 3-inch opening. The oversize (greater than three-inch) material from the vibrating grizzly is transferred to the secondary drum washer where it is water washed. The undersize (less than 3-inch) material from the vibrating bar grizzly is sent to the primary drum washer, which contains a ½-inch trommel screen at its outlet, and water washed. The greater than ½-inch material from the primary drum washer is sent to the secondary drum washer. The less than ½-inch material from the primary drum washer is sent to a vibrating double-deck screen for additional wet screening. This vibrating

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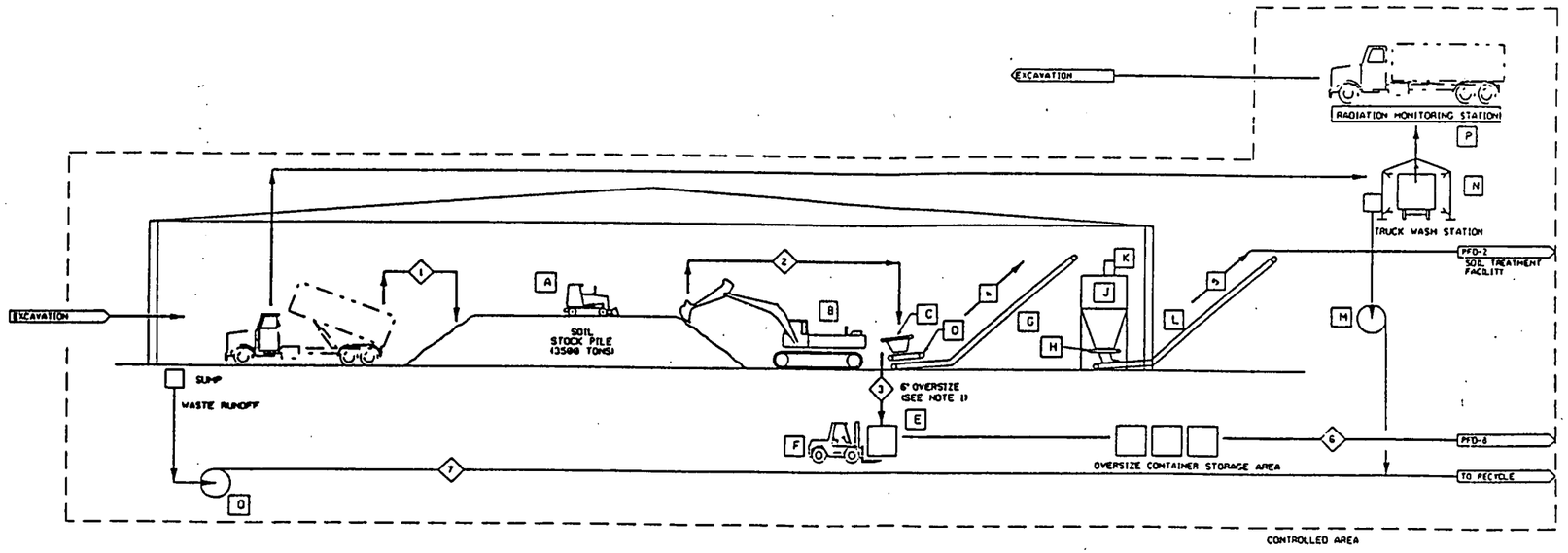

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STREAM NO.	1	2	3	4	5	6	7
COMPONENT	SOIL TO STORAGE PILE	STORAGE PILE TO FEED CON	OVERSIZE TO CONTAINERS	SOIL TO SOIL SILO	SOIL TO TREATMENT FACILITY	OVERSIZE TO MONITOR	WATER FROM PUMP
Operating Time (days/week)	5	7	7	7	7	7	
Operating Time (hours/day)	8	24	24	24	24	24	
Mass Flow (lbs/hour)	192,000	48,000		48,000	48,000	VARIES	
Mass Flow (tons/hour)	96	24	VARIES	24	24	VARIES	
Percent solids by weight	85	85	85	85	85	85	
Mass Flow (gpm)							100

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	2	TRACK LOADER
B	1	HYDRAULIC EXCAVATOR
C	1	VIBRATING GRIZZLY
D	1	APRON CONVEYOR
E	5	OVERSIZE CONTAINER
F	1	FORK LIFT
G	1	SOIL SILO FEED BELT CONVEYOR
H	1	APRON CONVEYOR
J	1	SOIL SILO 50 TON CAPACITY
K	1	DUST COLLECTOR
L	1	SOIL SILO DISCHARGE BELT CONVEYOR
M	4	SUMP PUMP
N	1	TRUCK WASH STATION
P	1	RADIATION MONITORING STATION
O	1	SUMP PUMP

NOTES:
1. OVERSIZED MATERIAL WILL CONSIST OF ROCKS, BRICK AND OTHER DEBRIS.

FIGURE L.2-2. PFD-1 INCOMING MATERIAL HANDLING FLOW DIAGRAM

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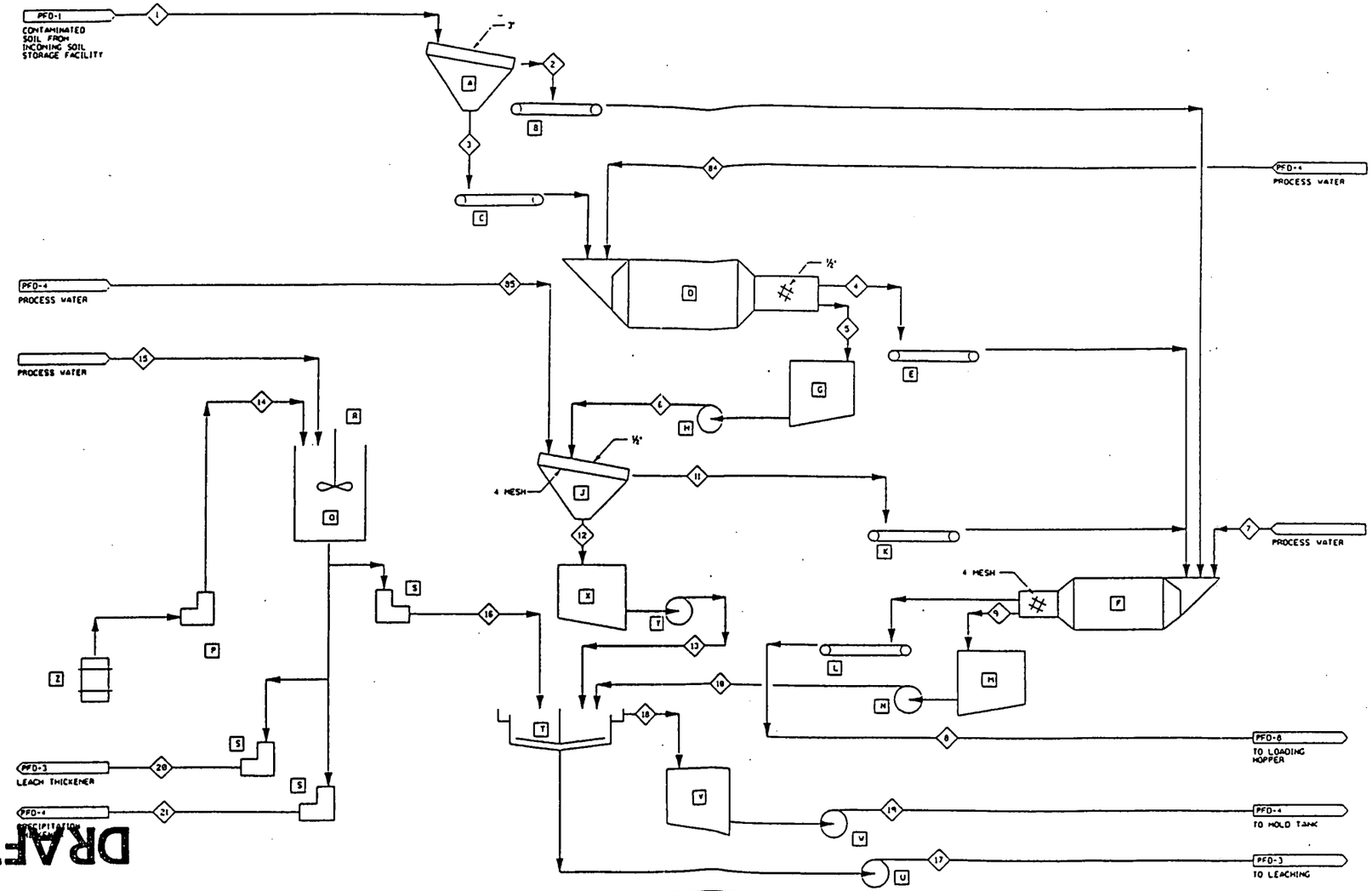

STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	84	85
COMPONENT	SOIL TO VIBRATE GRIZZLY	OVERSIZE TO 2nd WASH	UNDERSIZE TO PRIMARY WASH	OVERSIZE TO SEC. WASH	UNDERSIZE TO SUMP	SUMP TO D.D. SCREEN	PROC H2O TO SEC. DRM WASH	SEC. DRM WASH TO 4 MESH	SECOND. DRM WASH (4 MESH	(4 MESH TO THICKNER	OVERSIZE TO SEC. DRM WASH	UNDERSIZE TO SUMP	SUMP TO THICKENER	FLOCC TO MOLD TANK	PROC H2O TO FLOCC MAKEUP	FLOCC TO PRIM THICKNR	UNDERFLOW TO LEACHING	OVERFLOW TO PRIM. SUMP	P SUMP TO HOLD TANK	FLOCC TO LEACH THICKENER	FLOCC TO PREC. THICKENER	WASH H2O TO DRUM WASHER	PROC H2O TO D.D. SCREEN
OPERATING TIME (hrs/day)	24	24	24	24	24	24	24	24	24	24	24	24	24	INTERMIT	INTERMIT	24	24	24	24	24	24	24	24
SOLIDS (DRY) (lbs/hr)	34000.0	680.0	33320.0	566.0	32754.0	32754.0		1496.0	NEGLIBLE	NEGLIBLE	255.0	32504.0	32504.0	NOTE 2	NOTE 2	NOTE 2	32504.0						
MOISTURE (lbs/hr)	6000.0	120.0	5880.0	99.0	5781.0	5781.0		264.0	0.0	0.0	45.0	5736.0	5736.0				5736.0						
WATER (lbs/hr)				141.4	27298.6	27298.6	2992.0	377.1	2020.6	2020.6	64.3	92752.3	92752.3				20858.2	74714.7	74714.7			27448.8	65518.8
SODIUM BICARBONATE (lbs/hr)																							
SODIUM CARBONATE (lbs/hr)																							
POTASSIUM PERMANGHATE (lbs/hr)																							
SODIUM HYDROXIDE (lbs/hr)																							
STEAM (lbs/hr)																							
CARBON DIOXIDE (lbs/hr)																							
OTHER (lbs/hr)																							
MASS FLOW (lbs/hr)	40000.0	800.0	39200	801.4	65838.6	65838.6	2992.0	2137.1	2020.6	2020.6	364.3	130992.3	130992.3				59098.2	74714.7	74714.7			27448.8	65518.8
(gpm)					92.0	92.0	6.0		5.6	5.6	0.5	223.7	223.7				93.3	149.3	149.3			54.8	130.9
% SOLIDS (BY WEIGHT)	85.0	85.0	85.0	70.8	49.6	49.6	0.0	70.8	0.0	0.0	70.8	24.8	24.8				55.0	0.0	0.0			0.0	0.0
SOLIDS PARTICULATE SIZE																							
SPECIFIC GRAVITY ISOLIDS	2.5	2.5	2.5	2.5	2.5	2.5		2.5			2.5	2.5	2.5				2.5						
SPECIFIC GRAVITY SLURRY/WATER	2.041	2.041	2.041	1.724	1.429	1.429	1	1.724	1	1	1.429	1.170	1.170				1.266	1	1			1	1
TEMPERATURE (F)	70	70	70	70	70	70	70	70	70	70	70	70	70				70	70	70			70	70
URANIUM (mg/kg)																							

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	1	VIBRATING GRIZZLY
B	1	VIBRATING GRIZZLY OVERSIZE CONVEYOR
C	1	DRUM WASHER FEED CONVEYOR
D	1	DRUM WASHER W/TROMMEL SCREEN
E	1	DRUM WASHER DISCHARGE CONVEYOR
F	1	SECONDARY DRUM WASHER W/TROMMEL SCREEN
G	1	DRUM WASHER SUMP
H	2	DRUM WASHER SUMP PUMP
J	1	DOUBLE DECK SCREEN
K	1	DOUBLE DECK SCREEN CONVEYOR
L	1	SECONDARY DRUM WASHER DISCHARGE CONVEYOR
M	1	SECONDARY DRUM WASHER SUMP
N	2	SECONDARY DRUM WASHER SUMP PUMP
P	2	FLOCCULANT TRANSFER PUMP
Q	1	FLOCCULANT MAKE-UP TANK
R	1	FLOCCULANT MAKE-UP TANK AGITATOR
S	3	FLOCCULANT SUPPLY PUMP
T	1	PRIMARY THICKENER
U	2	PRIMARY THICKENER UNDERFLOW PUMP
V	1	PRIMARY THICKENER SUMP
W	2	PRIMARY THICKENER SUMP PUMP
X	1	DOUBLE DECK SCREEN SUMP
Y	2	DOUBLE DECK SCREEN SUMP PUMP
Z	-	FLOCCULANT DRUM

LEGEND

——— MAIN PROCESS LINE

——— SECONDARY PROCESS LINE

NOTES:

1. FLOWS SHOWN ARE FOR STEADY-STATE CONDITIONS.
2. FLOCCULANT IS ADDED TO THE PRIMARY THICKENER, CARBONATE LEACH THICKENER, AND SODIUM HYDROXIDE PRECIPITATE THICKENER AT A RATE OF 0.2, 0.15, AND 0.15 LB/TON DRY SOIL, RESPECTIVELY.

FIGURE L.2-3. PFD-2 WASHING, SCREENING, FLOCCULATION AND THICKENING

double-deck screen has a 0.157-inch lower screen and a ½-inch protective top screen. The greater than 0.157-inch material from the double-deck screen is transferred to the secondary drum washer, which contains a 0.157-inch trommel screen at its outlet, for a final water rinse. The greater than 0.157-inch water washed material is returned to the site as clean backfill after verification, and the less than 0.157-inch water washed material is sent to the primary thickener.

The less than 0.157-inch material from the double-deck screen is also sent to the primary thickener where flocculent is added to aid in the settling process. The thickener overflow is sent to a sump from where the overflow is pumped to the first wastewater hold tank. The thickener underflow (55 percent solids) is pumped to the leaching process.

L.2.2.3 Carbonate Leaching and Filtration

Figure L.2-4 provides a process flow design and a major equipment list for the carbonate leaching and filtration operations. As stated previously, the less than 0.157-inch materials have contaminants chemically bound to them, and therefore require a more aggressive treatment. In this operation, a carbonate/bicarbonate leaching solution is used to extract the contaminants from the soil into the leach solution. In conjunction with leaching, attrition scrubbing is incorporated to aid in the contaminant extraction process. Attrition scrubbing is a process in which the soil particles are caused to violently collide with themselves. This interaction abrades each soil particle and separates the smaller uranium particles from the larger clean soil particles. The 55 percent solids underflow from the primary thickener is received in the first in a series of three agitated reactor scrubbers. These reactor scrubbers act as combination attrition scrubbers/leach tanks. The reagents carbonate/bicarbonate and potassium permanganate are added to the first reactor scrubber along with the 55 percent soil slurry. Enough recycle carbonate solution is added to drop the solids concentration down to 35 percent. This process is designed to take place at a temperature of 40°C; therefore, steam is added to each of the reactor scrubbers to raise and maintain the temperature of the scrubbing/leaching solution. The reactor scrubbers have a total residence time of 1.25 hours, which allows ample time for all reactions to occur.

After leaving the reactor scrubbers, the soil slurry is pumped to the leach thickener where flocculent is added to aid in the settling process. The overflow from the leach thickener is sent to a sump from which the overflow is pumped to the precipitation process. The leach thickener underflow (55 percent solids) is pumped to the leach belt filter holding tank, which feeds the leach belt filter. The filter cake is washed with process water before discharge and is then discharged at approximately

75 percent solids. This cake is containerized and monitored for contamination. Filter cake with contaminant concentrations at or below the WAC may be conditioned with sand, if necessary, to increase the solids content for material handling purposes and backfilled or consolidated with an

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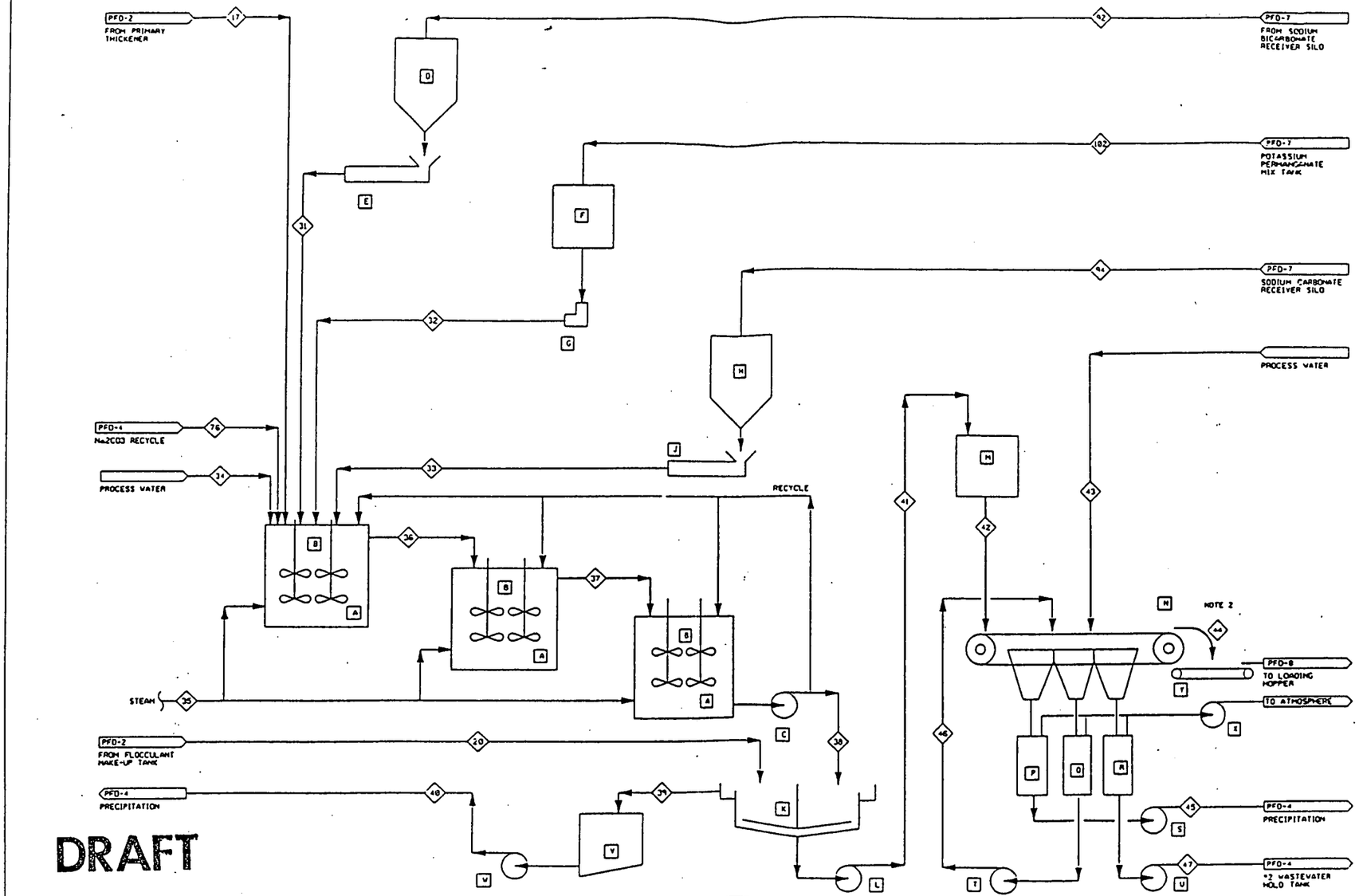

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STREAM NO.	17	20	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	76	92	94	102
COMPONENT	UNDERFLOW TO LEACH	FLOCC TO LEACH THICKENER	NaHCO3 TO LEACH TANK #1	KMnO4 TO LEACH TANK #1	Na2CO3 TO LEACH TANK #1	WATER TO LEACH TANK #1	STEAM TO LEACH TK	TANK #1 TO TANK #2	TANK #2 TO TANK #3	TANK #3 TO THICKENER	THICKENER OVERFLOW TO SUMP	LEACH SLURRY TO PRECIP	THICKENER UNDERFLOW TO HOLD	HOLD TO BELT FILTER	PROC H2O TO #1 BELT FIL.	TREATED SOIL TO MONITOR	BELT FILTER TO PRECIP	BELT FILTER #1 TO RECYC	BELT FILT #2 HOLD	Na2CO3 RECYCLE TO LEACH	NaHCO3 TO DAY TANK	Na2CO3 TO DAY TANK	KMnO4 TO DAY TANK
OPERATING TIME (hrs/day)	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	INTER.	INTER.	INTER.
SOLIDS (lbs/hr)	32594.8					INTER.		32046.4	32046.4	32046.4	0.0	0.0	32046.4	32045.4		32046.4		INTERNAL					
MOISTURE (lbs/hr)	5736.8							5655.2	5655.2	5655.2	0.0	0.0	5655.2	5655.2		5655.2							
RECYCLED/CLEAN WATER (lbs/hr)	20858.2			1544.9				58393.1	58393.1	58393.1	37828.6	37828.6	20564.5	20564.5	64892.8	5826.9	20564.5		5965.9	32225.5			
SODIUM BICARBONATE (lbs/hr)			515.6					1088.4	1088.4	1088.4	595.6	595.6	412.8	412.8			330.2		82.6	22.6			
SODIUM CARBONATE (lbs/hr)					235.2			68.6	68.6	68.6	40.5	40.5	28.1	28.1			22.5		5.6	444.8			
PERMANGANATE (lbs/hr)				100.0				0.0	0.0	0.0	0.0	0.0	0.0	0.0									
SODIUM HYDROXIDE (lbs/hr)																							
STEAM (lbs/hr)							3683.8																
CARBON DIOXIDE (lbs/hr)																							
OTHER (lbs/hr)								457.6	457.6	457.6			457.6	457.6			457.6						
TOTAL FLOWRATE (lbs/hr)	59098.2		515.6	1644.9	235.2		3683.8	97629.3	97629.3	97629.3	38464.7	38464.7	59164.7	59164.7	64892.8	42728.5	21374.8		59154.1	32592.1			
(gpm)	93.3							154.9	154.9	154.9	76.8	76.8	82.7	82.7	128.0		42.5		117.7	65.3			
% SOLIDS (BY WEIGHT)	55.0		0.0	6.1	100.0			33.3	33.3	33.3	0.0	0.0	55.0	55.0		75.0	0.0		0.0	1.4			
SPECIFIC GRAVITY (SOLIDS)	2.5							2.5	2.5	2.5			2.5	2.5		2.5							
SPECIFIC GRAVITY (SLURRY)	1.266							1.299	1.299	1.299	1	1	1.429	1.429	1	1.819	1		1	1			
BULK DENSITY (lbs/ft3)																							
TEMPERATURE (F)			70.0	70.0	70.0	70.0	365	115.0	115.0	115.0	115.0	115.0	115.0	115.0	70.0	81.0	81.0		81.0	84.00			68.0
URANIUM (mg/kg)																							

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	3	REACTOR SCRUBBERS
B	6	REACTOR SCRUBBER AGITATORS
C	2	REACTOR SCRUBBER TRANSFER PUMP
D	1	SODIUM BICARBONATE DAY TANK
E	1	SODIUM BICARBONATE FEEDER
F	1	POTASSIUM PERMANGANATE DAY TANK
G	2	POTASSIUM PERMANGANATE METERING PUMP
H	1	SODIUM CARBONATE DAY TANK
J	1	SODIUM CARBONATE FEEDER
K	1	LEACH THICKENER
L	2	LEACH THICKENER TRANSFER PUMP
M	1	LEACH BELT FILTER FEED TANK
N	2	LEACH BELT FILTER
P	2	FILTRATE TANK NO. 1
Q	2	FILTRATE TANK NO. 2
R	2	FILTRATE TANK NO. 3
S	2	FILTRATE PUMP NO. 1
T	2	FILTRATE PUMP NO. 2
U	2	FILTRATE PUMP NO. 3
V	1	LEACH THICKENER SUMP
W	2	LEACH THICKENER SUMP PUMP
X	2	LEACH BELT FILTER VACUUM PUMP
Y	1	LEACH BELT FILTER BELT CONVEYOR

LEGEND

- MAIN PROCESS LINE
- SECONDARY PROCESS LINE
- FUTURE PIPING
- FUTURE EQUIPMENT

NOTES:

1. FLOWS SHOWN ARE FOR STEADY-STATE CONDITIONS.
2. TWO BELT FILTERS ARE USED. MATERIAL BALANCE REFLECTS TOTAL FLOW TO BOTH BELT FILTERS. EACH FILTER WILL HANDLE ONE-HALF THE TOTAL FLOW.

FIGURE L.2-4. PFD-3 CARBONATE LEACHING AND FILTRATION

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earthen cover. Filter cake with contaminant concentrations exceeding the WACs for backfill or consolidation would be transported to the sulfuric acid leaching operation (a maximum rate of 1.7 dry tons per hour, which represents 10 percent of the initial dry soil feed rate to carbonate leaching, was chosen to minimize the sulfate ion concentration in the effluent) for further treatment. Any remaining contaminated soil above and beyond 1.7 dry tons per hour would be stabilized, containerized, and shipped off site for disposal.

The filtrate from the belt filter is collected in three separate zones. Filtrate from the first zone near the beginning of the belt filter would be concentrated with the contaminants removed from the soil. Therefore, it would be pumped to the precipitation operation. Filtrate from the second zone is recycled back to the belt filter to aid in washing the filter cake. Filtrate from the last zone is comprised mainly of the process water used to wash the filter cake and a small level of contaminants. This filtrate is sent to the second wastewater hold tank.

L.2.2.4 Sodium Hydroxide Precipitation

The carbonate leaching operation extracted contaminants from the soil into the leaching solution. The precipitation step, in turn, removes the contaminants from the leaching solution by making the contaminants insoluble, resulting in the contaminants dropping out of solution as solids. Figure L.2-5 provides a process flow diagram and a major equipment list for the sodium hydroxide precipitation operation.

The overflow from the leach thickener and the filtrate from the first zone of the leach belt filter are received in the first in a series of two precipitation tanks along with the precipitation reagent sodium hydroxide. The precipitation tanks have a total residence time of 4.5 hours, which allows ample time for all reactions to occur.

After leaving the precipitation tanks, the soil slurry is pumped to the precipitate thickener where flocculants are added to aid in the settling process. The overflow from the precipitate thickener is sent to a sump from where the overflow is pumped to the second wastewater holding tank. The precipitate thickener underflow (35 percent solids) is pumped to the precipitate belt filter holding tank, which feeds the precipitate belt filter. The filter cake is washed with process water before discharge and is then discharged at a 70 percent solids level. This cake is essentially the concentrated uranium fraction. Therefore, it is stabilized, containerized, and shipped off site for disposal. The filtrate from the precipitate belt filter is pumped to the second wastewater holding tank.

A portion of the effluent from the second wastewater hold tank is sent to a regeneration tank where carbon dioxide is introduced to react with the remaining sodium hydroxide, producing sodium carbonate. This regenerated sodium carbonate solution is recycled to the leaching process. The

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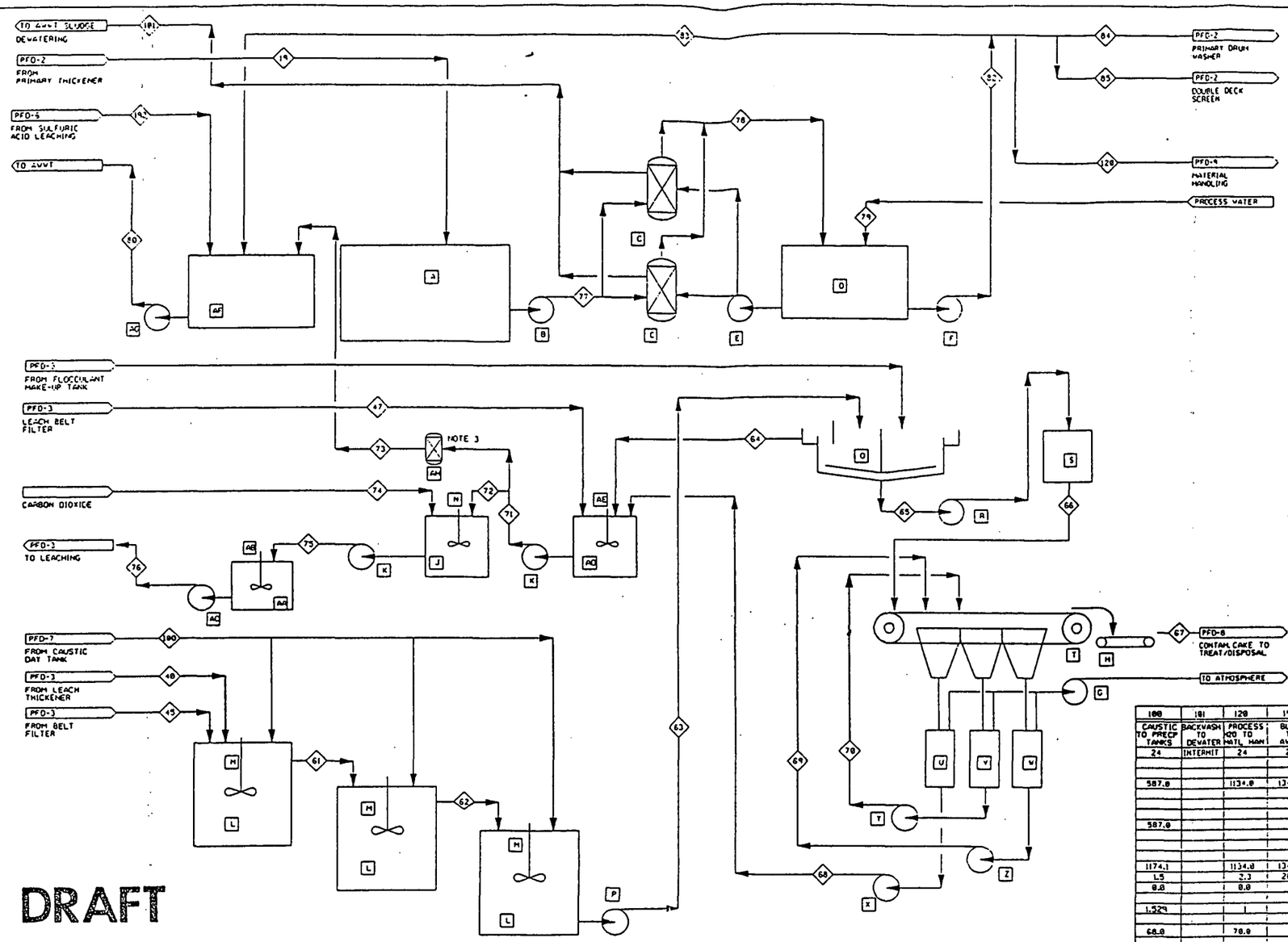

100	101	120	192
CAUSTIC TO PRECIP TANKS	BACKWASH TO DEWATER	PROCESS H2O TO MTL HAN	BLEED TO AWWT
24	INTERMIT	24	24
587.0		1134.0	13438.0
587.0			
			4
1174.1		1134.0	13442.0
1.5		2.3	26.8
0.0		0.0	
1.529		1	1
68.0		78.0	

STREAM NO.	19	40	45	47	61	62	63	64	65	66	67	68	69/70	71	72	73	74	75	76	77	78	79	80	82	84	85
COMPONENT	P SUMP TO HOLD TANK	LEACH SUMP TO PREC.	BELT FILTR TO PRECIP	BELT FILTR TO #2 HOLD	PREC TK #1 TO PR TK #2	PREC TK #2 TO PR TK #3	PREC TANK TO THICKENER	THICKENR OVFLO TO #2 HOLD	THICKENR UNDRFLOW TO HOLD	HOLD TK TO BELT FILTER	CNT CAKE TO DISP/TREATMNT	BLT FLTR TO #2 HOLD	BELT FILTER RECYCLE	#2 HOLD DISCHARG	#2 HOLD TO RECARB	#2 HOLD TO AWWT	CO2 TO RECARB TANK	RECAR TO Na2CO3 HOLD	Na2CO3 RECYC TO LEACHING	WST WATR TO MEDIA FILTERS	WST WATR TO RCYCL STORAGE	CLN H2O MAKEUP FEED	WATER TO AWWT	RECYCLE STORAGE DISCHARG	RECYCLE TO AWWT FEED TK	WASH H2O TO DRUM WASHER
OPERATING TIME (hrs/day)	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	INTERMIT	INTERMIT	24	24	24
SOLIDS (DRY) (lbs/hr)		0.0											INTERNAL													
MOISTURE (lbs/hr)		0.0																								
RECYCLED/CLEAN WATER (lbs/hr)	74714.7	37828.6	28564.5	59065.9	58980.2	58980.2	58980.2	58182.8	797.4	797.4	184.8	613.4		1176621	32225.5	85636.5		32225.5	22225.5	74714.7	74714.7	19377.3	99874.5	94892.0	0.0	27440.0
SODIUM BICARBONATE (lbs/hr)		595.6	338.2	82.6	0.0	0.0	0.0							82.6	22.6	60.0		22.6	22.6				60.0			
SODIUM CARBONATE (lbs/hr)		40.5	22.5	5.6	1231.3	1231.3	1231.3	1214.6	16.6	16.6		16.6		1236.9	338.2	898.7		444.0	444.0				898.7			
POTASSIUM PERMANGNATE (lbs/hr)		0.0																								
SODIUM HYDROXIDE (lbs/hr)					292.1	292.1	292.1	288.1	3.9	3.9		3.9		292.1	79.9	212.2							212.2			
STEAM (lbs/hr)																										
CARBON DIOXIDE (lbs/hr)																	43.9									
OTHER (lbs/hr)			457.6		429.4	429.4	429.4	0.0	429.4	429.4	429.4												4.0			
MASS FLOW (lbs/hr)	74714.7	38464.7	21374.8	59154.1	60932.8	60932.8	60932.8	59685.5	1247.3	1247.3	613.4	634.0		1194735	32666.1	86887.4	43.9	32692.1	22692.1	74714.7	74714.7	19377.3	100274.4	94892.0	0.0	27440.0
(gpm)	149.3	76.8	42.5	117.7	120.5	120.5	120.5	119.2	2.0	2.0	1.2	1.2		238.3	64.6	137.0		65.3	45.3	149.3	148.8	38.7	200.3	187.4	0.0	54.8
% SOLIDS (BY WEIGHT)	0.0	0.0	0.0	0.0	2.7	2.7	2.7	2.8	35.0	35.0	70.0	2.6		1.0	1.0	1.0		1.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLIDS PARTICULATE SIZE (%)																										
SPECIFIC GRAVITY (SOLIDS)			2.5	2.5	2.5	2.5	2.5																			
SPECIFIC GRAVITY (SLURRY/WATER)	1	1		1	1	1	1	1	1.266	1.266	1.724	1		1	1	1		1	1	1	1	1	1	1	1	1
TEMPERATURE (F)		115.0	81.0	81.0	68.0	84.0	84.0	90.0	90.0	90.0	78.0	78.0		90.0	90.0	90.0		89.00	89.00	89.00	89.0	89.0	89.0	89.0	89.0	89.0
URANIUM (mg/kg)																										

STREAM NO.	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
COMPONENT	WATER TO AWWT	RECYCLE STORAGE DISCHARG	RECYCLE TO AWWT FEED TK	WASH H2O TO DRUM WASHER	WASH H2O TO D.D. SCREEN																					
OPERATING TIME (hrs/day)	INTERMIT	24	24	24	24																					
SOLIDS (DRY) (lbs/hr)																										
MOISTURE (lbs/hr)																										
RECYCLED/CLEAN WATER (lbs/hr)	99874.5	94892.0	0.0	27440.0	69516.0																					
SODIUM BICARBONATE (lbs/hr)	60.0																									
SODIUM CARBONATE (lbs/hr)	898.7																									
POTASSIUM PERMANGNATE (lbs/hr)																										
SODIUM HYDROXIDE (lbs/hr)	212.2																									
STEAM (lbs/hr)																										
CARBON DIOXIDE (lbs/hr)																										
OTHER (lbs/hr)	4.0																									
MASS FLOW (lbs/hr)	100274.4	94892.0	0.0	27440.0	69516.0																					
(gpm)	187.4	0.0	0.0	54.8	138.9																					
% SOLIDS (BY WEIGHT)	0.0	0.0	0.0	0.0	0.0																					
SOLIDS PARTICULATE SIZE (%)																										
SPECIFIC GRAVITY (SOLIDS)																										
SPECIFIC GRAVITY (SLURRY/WATER)	1	1	1	1	1																					
TEMPERATURE (F)	89.0	89.0	89.0	89.0	89.0																					
URANIUM (mg/kg)																										

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	1	*1 WASTEWATER HOLD TANK
B	2	*1 WASTEWATER HOLD TANK TRANSFER PUMP
C	2	MULTI-MEDIA FILTER
D	1	RECYCLE WATER STORAGE TANK
E	2	BACKWASH PUMP
F	2	RECYCLE WATER SUPPLY PUMP
G	1	PRECIPITATE BELT FILTER VACUUM PUMP
H	1	PRECIPITATE BELT FILTER BELT CONVEYOR
J	1	RECARBONATION TANK
K	2	*2 WASTEWATER HOLD TANK PUMP
L	3	PRECIPITATION TANK
M	3	PRECIPITATION TANK MIXER
N	1	RECARBONATION TANK AGITATOR
P	2	PRECIPITATE TANK TRANSFER PUMP
Q	1	PRECIPITATE THICKENER
R	2	PRECIPITATE THICKENER TRANSFER PUMP
S	1	PRECIPITATE BELT FILTER FEED TANK
T	1	PRECIPITATE BELT FILTER
U	1	FILTRATE TANK NO. 4
V	1	FILTRATE TANK NO. 5
W	1	FILTRATE TANK NO. 6
X	1	FILTRATE PUMP NO. 4
Y	1	FILTRATE PUMP NO. 5
Z	1	FILTRATE PUMP NO. 6
AA	1	RECYCLE SODIUM CARBONATE STORAGE TANK
AB	1	RECYCLE SODIUM CARBONATE STOR. TANK AGITATOR
AC	2	RECYCLE SODIUM CARBONATE STORAGE TANK PUMP
AD	1	*2 WASTEWATER HOLD TANK
AE	1	*2 WASTEWATER HOLD TANK AGITATOR
AF	1	AWWT FEED TANK
AG	2	AWWT FEED TANK PUMP
AH	1	MULTIMEDIA FILTER

LEGEND

——— MAIN PROCESS LINE

——— SECONDARY PROCESS LINE

NOTES:
1. FLOWS SHOWN ARE FOR STEADY-STATE CONDITIONS.
2. ALL FILTER BACKWASH WILL BE SENT TO THE AWWT SLUDGE DEWATERING SYSTEM.
3. DETAILED PIPING CONFIGURATION AROUND FILTER NOT SHOWN. HOWEVER, FILTER WILL BE BACKWASHED, AND BACKWASH SENT TO AWWT SLUDGE DEWATERING.

FIGURE L.2-5. PFD-4 SODIUM HYDROXIDE PRECIPITATION

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remaining portion of the effluent from the second wastewater holding tank is filtered, then sent to the AWWT facility for further treatment. The collected quantities in the first wastewater holding tank are pumped through multimedia filters to remove particulate matter. The effluent from the multi-media filters is transferred to the recycle water storage tank.

This water is recycled to the primary drumwasher, the double-deck screen, the leach belt filter, and material handling for slurrying any filter cake going to sulfuric acid leaching. Any required makeup water to the recycle water tank is provided by process water. If necessary, a portion of the recycle water can be bled to the AWWT facility.

L.2.2.5 Sulfuric Acid Leaching and Filtration

The objective of sulfuric acid leaching is to reduce the uranium concentration in the off-specification soil exiting the carbonate leaching system to the level defined by the WAC. Figure L.2-6 provides a process flow diagram and a major equipment list for the sulfuric acid leaching and filtration operation. Carbonate leaching filter cake with contaminant concentrations exceeding the WAC would be reslurried with water to obtain a 60 percent solids slurry, then pumped to the sulfuric acid leaching operation for further treatment at a maximum rate of 1.7 tons per hour (based on dry solids). The feed slurry is discharged into the first of three sulfuric acid reactor scrubbers. Additional water is added to the first scrubber to produce a slurry with a 35 percent solids content. The leaching reagent (98 percent sulfuric acid) is then added to the reactor scrubber to establish a 1.5 to 2.0 Normal (N) concentration in the solution, and is controlled to maintain a free acid concentration of 6.5 grams per liter in the leach discharge stream, after all the required leaching activity is complete. The sulfuric acid leach circuit is designed to provide a leaching time of one hour, and saturated steam is directly injected into the leach tanks to maintain a leaching temperature of 40°C. Just as in the carbonate leaching operation, attrition scrubbing is also incorporated in the sulfuric acid leaching operation to liberate locked-in uranium particles from the larger soil particles, making them more accessible for leaching.

Leached soil slurry is pumped to a thickener where flocculent is added to aid in the settling process. The overflow from the leach thickener is ultimately sent to calcium hydroxide precipitation, and the leach thickener underflow (at 55 percent solids) is sent to a vacuum belt filter for solids/liquid separation. The cake from the belt filter is washed with clean process water in a countercurrent fashion, then conveyed to sampling/monitoring at a 75 percent solids content. Filter cake that is at or below the PRLs may be conditioned with sand, if necessary, for material handling purposes and returned to the site as backfill. Filter cake that exceeds the PRLs is stabilized, containerized, and shipped off site for disposal.

The filtrate from the vacuum belt filter is collected in three separate zones (typical). The filtrate from the first zone is highly concentrated with the contaminants removed from the soil; therefore, it is sent to the calcium hydroxide precipitation operation. The filtrates from the second and third zones are recycled back to the filter to aid in cake washing.

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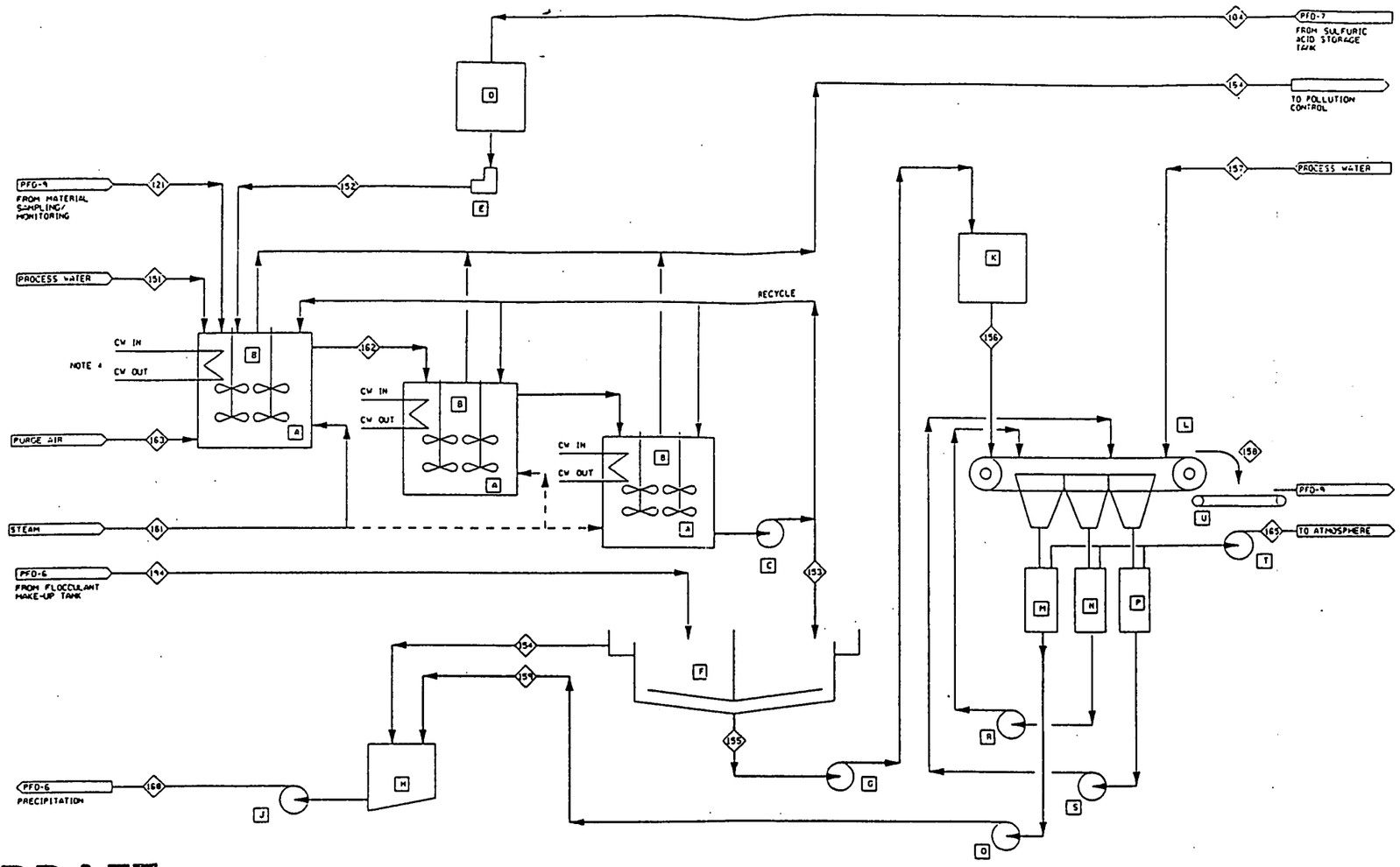

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STREAM NO.		104	121	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	194
COMPONENT		SULFURIC ACID DAY SUPPLY	FEED TO SULFACID LEACH	WATER ADDITION	SULFURIC ACID ADDITION	SULFACID LEACH DISCH	LEACH THICKR O'FLOW	LEACH THICKR U'FLOW	LEACH FILTER FEED	WASH H2O TO LEACH FILTER	ACID LCH TREATED SOIL	LEACH FILTER FILTRATE	TOTAL FEED TO PRECIP.	STEAM INJECT	TOT FEED TO SULF ACID LEC	PURGE AIR	VENT	VENT AIR	FLOCC. TO LEACH THICKR
OPERATING TIME	(hrs/day)	0.5	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
SOLIDS:																			
SOIL (DRY)	(lbs/hr)		3488			2989		2989	2989		2989				3488				
PRECIPITATES	(lbs/hr)					458		458	458		458								
$Ca(OH)_2$	(lbs/hr)																		
SOLUTION :																			
WATER	(lbs/hr)		2260	4854	13	6773	4147	2626	2626	8686	1159	10874	14221		6327				
DISSOLVED SALT	(lbs/hr)					397	231	166	166		1.42	164.6	395.6						
H_2SO_4					636	68	41.6	26.4	26.4		0.8	25.6	67.2		636				
SO_4						19	11.6	7.4	7.4		0.2	7.2	18.8						
GAS :																			
CO_2/O_2	(lbs/hr)																107/		
STEAM/AIR	(lbs/hr)													435	435/16.3	16.3	111.3	750	
MASS FLOW	(lbs/hr)	15,576/Day	5668	4854	649	10896	4,431	6265	6,265	8686	4680	10871	14702		10814	16.3	118.3	750	
VOLUMETRIC FLOW	(gpm)	34	7.3	8.1	0.71	16.6	8.5	8.1	8.2	17.2	5.1	20.3	29.7		16.1				
VOLUMETRIC FLOW	(SCFM)													84		3.6	19.1	160	
%SOLIDS/SOLUTION (BY WEIGHT)		98	60		98	32/		55/	55/		75/				32/				
SPEC GRAVITY SOIL/PRECIP			2.5/			2.5/2.37		2.5/2.37	2.5/2.37		2.5/2.37				2.5/				
SPEC GRAVITY SLURRY/SOLUTION		1.84	1.56/1.0	1.0	1.84	1.29/1.04	1.84	1.53/1.04	1.53/1.04	1.0	1.02/1.04	1.04	1.04		1.29/1.0				
TEMPERATURE	(F)	70	70	70	70	104	104	104	104	70	76	76	93	268	104		104		
URANIUM	(PPM)																		
NOTES:																			
									NOTE 2										NOTE 3

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	3	REACTOR SCRUBBERS
B	6	REACTOR SCRUBBER AGITATORS
C	2	REACTOR SCRUBBER TRANSFER PUMP
D	1	SULFURIC ACID DAY TANK
E	1	SULFURIC ACID METERING PUMP
F	1	LEACH THICKENER
G	2	LEACH THICKENER TRANSFER PUMP
H	1	LEACH THICKENER OVERFLOW TANK
J	2	LEACH THICKENER OVERFLOW PUMP
K	1	LEACH BELT FEEDER FEED TANK
L	2	LEACH BELT FILTER
M	2	FILTRATE TANK #1
N	2	FILTRATE TANK #2
P	2	FILTRATE TANK #3
Q	2	FILTRATE PUMP #1
R	2	FILTRATE PUMP #2
S	2	FILTRATE PUMP #3
T	1	LEACH BELT FILTER VACUUM PUMP
U	1	TREATED SOIL TRANSFER CONVEYOR

LEGEND

- MAIN PROCESS LINE
- SECONDARY PROCESS LINE
- FUTURE PROCESS LINE
- FUTURE EQUIPMENT
- ALTERNATE PROCESS LINE

NOTES:

1. FLOWS SHOWN ARE FOR STEADY-STATE CONDITIONS.
2. TWO BELT FILTERS ARE USED. MATERIAL BALANCE REFLECTS TOTAL FLOW TO BOTH BELT FILTERS. EACH FILTER WILL HANDLE ONE-HALF THE TOTAL FLOW.
3. FLOCCULANT #1 IS ADDED TO THE LEACH THICKENER AT THE RATE OF 0.2 LB/TON DRY SOIL. NOT INCLUDED IN BALANCE.
4. STEAM OR COOLING WATER IS PROVIDED TO MAINTAIN LEACHING TEMPERATURE AT 104° F. STEAM FOR HEATING WILL BE BY DIRECT INJECTION, AND PROCESS COOLING WATER WILL BE PROVIDED THROUGH COOLING COILS.

FIGURE L.2-6. PROCESS FLOW DIAGRAM SULFURIC ACID

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L.2.2.6 Calcium Hydroxide Precipitation

The total feed to the calcium hydroxide precipitation operation is comprised of the sulfuric acid leach thickener overflow and the concentrated contaminant filtrate from the sulfuric acid leach vacuum belt filter. The objective of the calcium hydroxide precipitation operation is to remove dissolved contaminants from the leaching solution as insoluble solid particles, then separate these insoluble solids from solution for disposal. Figure L.2-7 provides a process flow diagram and a major equipment list for the calcium hydroxide precipitation operation. The feed is received in the first in a series of three precipitation tanks. The precipitation reagent, calcium hydroxide, is added to the first precipitation tank. The precipitation circuit is designed for retention time of two hours. The slurry discharged from the precipitation process is pumped to the precipitation thickener, where flocculants are added to aid in the settling process. The precipitation thickener overflow and required flocculants are fed to a reactor clarifier, where the turbidity of the influent is reduced to less than 50 parts per million (ppm). The clarifier overflow is ultimately sent to the AWWT facility for treatment after filtration, while the clarifier underflow (20 percent solids) and the precipitate thickener underflow (25 percent solids) are fed to the precipitate vacuum belt filter for solids/liquid separation.

The filter cake is washed in a countercurrent fashion with process water, and the final filter cake is discharged at a solids content of approximately 50 percent. This cake is then stabilized, containerized, and shipped off site for disposal.

The filtrate collected from the first zone of the vacuum belt filter is ultimately sent to the AWWT facility for treatment after filtration. The filtrate collected from the second and third zones is recycled back to the filter to aid in cake washing.

L.2.2.7 Reagent Receipt and Handling

The sodium bicarbonate, sodium carbonate, calcium hydroxide, caustic soda, sulfuric acid, and potassium permanganate reagents are supplied to the soil washing facility via tank trucks. Figure L.2-8 provides a process flow diagram and a major equipment list for the reagent receipt and handling operations. Sodium bicarbonate, sodium carbonate, calcium hydroxide, and potassium permanganate are brought in as dry materials and unloaded to their respective storage silos. From their storage silos, sodium bicarbonate, sodium carbonate, and calcium hydroxide are pneumatically conveyed to their respective day bins, from which they are conveyed to the process at predetermined rates. The potassium permanganate is metered by conveyor from the storage silo to a makeup tank, where a potassium permanganate solution is made, then pumped to a day tank.

Caustic soda is supplied to the soil washing facility as liquid in the form of 50 percent sodium hydroxide solution. The caustic soda is pumped from the tank truck to the caustic soda storage tank. From the storage tank, caustic soda is transferred to a day tank, from which the process is supplied. Sulfuric acid is supplied to the soil washing facility as liquid in the form of 98 percent sulfuric acid solution. From the storage tank, sulfuric acid is transferred to a day tank where the acid is added to water for dilution if required. Sulfuric acid is supplied to the process from the day tank. The staging

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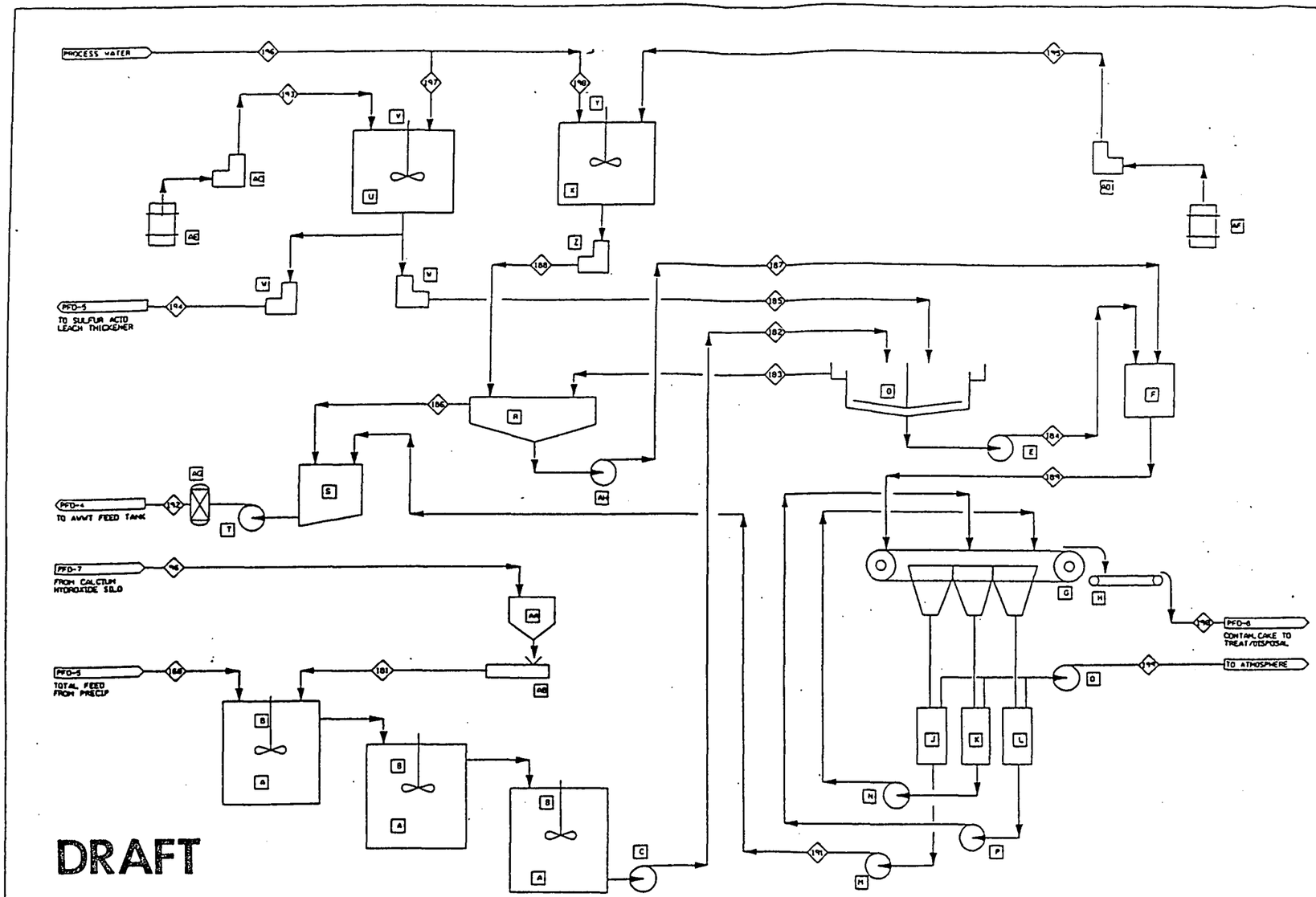

STREAM NO.		196	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199
COMPONENT		CALC. HYDR DAY SUPPLY	TOTAL FEED TO PRECIP.	CALC. HYDR TO PRECIP.	PRECIP. OSCHL	PRECIP. THICKNR O'FLOW	PRECIP. THICKR. U'FLOW	FLOC. #1 TO PREC THIKNR	CLARIFIER O'FLOW	CLARIFIER U'FLOW	FLOC. #2 TO CLARIFIER	FEED TO PRECIP. FILTER	CONTAM. CAKE TO DISPOSAL	FILTRATE TO CLAR. SUMP	BLEED TO AWWT	FLOC. #1 TO MAKE-UP TANK	FLOC. #1 TO LEACH THICK	FLOC. #2 TO MAKE-UP TANK	FLOC WATER SUPPLY	WATER TO FLOC #1	WATER TO FLOC #2	VENT AIR
OPERATING TIME	(hrs/day)	1.0	INTERM	24	24	24	24	INTERM.	24	24	24	24	24	24	24	INTERM	24	INTERM	INTERM	INTERM	INTERM	INTERM
SOLIDS:																						
SOIL LOAM	(lbs/hr)																					
PRECIPITATES	(lbs/hr)				830	54	776			54		830	830									
$CaSO_4 \cdot 2$	(lbs/hr)	7000		312	48	6	42			6		48	48									
SOLUTION :																						
WATER	(lbs/hr)	156	14221	13	14118	11664	2454		11424	240		2694	678	1816	13244							
DISSOLVED SALT	(lbs/hr)		395.6		31	25	6		25			6	2	4	4							
H_2SO_4			67.2																			
SO_4			18.8																			
GAS :																						
CO_2/N_2	(lbs/hr)																					
STEAM/AIR	(lbs/hr)																					750
MASS FLOW	(lbs/hr)		14782	325	15027	11749	3278		11449	300		3578	1758	1820	13244							750
VOLUMETRIC FLOW	(gpm)		28.7		29	22.6	6.7		22.0	6.6		6.2	1.8	3.9	26.5							
VOLUMETRIC FLOW	(scfm)																					160
% SOLIDS/SOLUTION	(BY WEIGHT)	98/		98/	5.5/	0.5	25/			20		22.0/	50/									
SPEC GRAVITY SOIL/PRECIP					/2.32	/2.32	/2.32			/2.32		/2.32	/2.37									
SPEC GRAVITY SLURRY/SOLUTION		1.2/	/1.04	1.2/		/1.04			/1.04	1.31/1.04		1.15/1.0	1.93/1.0	/1.0	/1.0							
TEMPERATURE	(F)	70	93	70	90	85	85		82	82		80	80	80	80							
URANIUM	(PPM)																					
NOTES:								NOTE 2			NOTE 3											

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	3	PRECIPITATION TANK
B	3	PRECIPITATION TANK MIXER
C	2	PRECIPITATE TANK TRANSFER PUMP
D	1	PRECIPITATE THICKENER
E	2	PRECIPITATE THICKENER TRANSFER PUMP
F	1	PRECIPITATE BELT FILTER FEED TANK
G	1	PRECIPITATE BELT FILTER
H	1	PRECIPITATE BELT FILTER CAKE CONVEYOR
J	1	FILTRATE TANK #4
K	1	FILTRATE TANK #5
L	1	FILTRATE TANK #6
M	1	FILTRATE PUMP #4
N	1	FILTRATE PUMP #5
P	1	FILTRATE PUMP #6
Q	1	PRECIPITATE BELT FILTER VACUUM PUMP
R	1	PRECIPITATE THICKENER OVERFLOW CLARIFIER
S	1	CLARIFIER OVERFLOW TRANSFER SUMP
T	1	CLARIFIER OVERFLOW TRANSFER PUMP
U	1	FLOCCULANT #1 MAKE-UP TANK
V	1	FLOCCULANT #1 MAKE-UP TANK AGITATOR
W	2	FLOCCULANT #1 MAKE-UP TANK METERING PUMP
X	1	FLOCCULANT #2 MAKE-UP TANK
Y	1	FLOCCULANT #2 MAKE-UP TANK AGITATOR
Z	1	FLOCCULANT #2 MAKE-UP TANK METERING PUMP
AA	1	CALCIUM HYDROXIDE DAY HOPPER
AB	1	CALCIUM HYDROXIDE FEEDER
AC	2	FLOCCULANT #1 TRANSFER PUMP
AD	2	FLOCCULANT #2 TRANSFER PUMP
AE	1	#1 FLOCCULANT DRUM
AF	1	#2 FLOCCULANT DRUM
AG	1	MULTIMEDIA FILTER
AH	2	CLARIFIER UNDERFLOW TRANSFER PUMP

LEGEND

- MAIN PROCESS LINE
- SECONDARY PROCESS LINE
- FUTURE PROCESS LINE
- FUTURE EQUIPMENT
- ALTERNATE PROCESS LINE

NOTES

1. FLOWS SHOWN ARE FOR STEADY-STATE CONDITIONS.
2. FLOCCULANT NUMBER ONE IS ADDED TO THE PRECIPITATOR THICKENER AT A RATE OF 2.2 POUNDS PER TON OF DRY PRECIPITATE NOT INCLUDED IN THE BALANCE.
3. REAGENT FLOCCULANT NUMBER TWO IS ADDED TO THE CLARIFER AS REQUIRED. NOT INCLUDED IN THE BALANCE.
4. ALL FILTER BACKWASH WILL BE SENT TO THE AWWT SLUDGE DEWATERING SYSTEM.

FIGURE L.2-7. PROCESS FLOW DIAGRAM
CALCIUM HYDROXIDE PRECIPITATION

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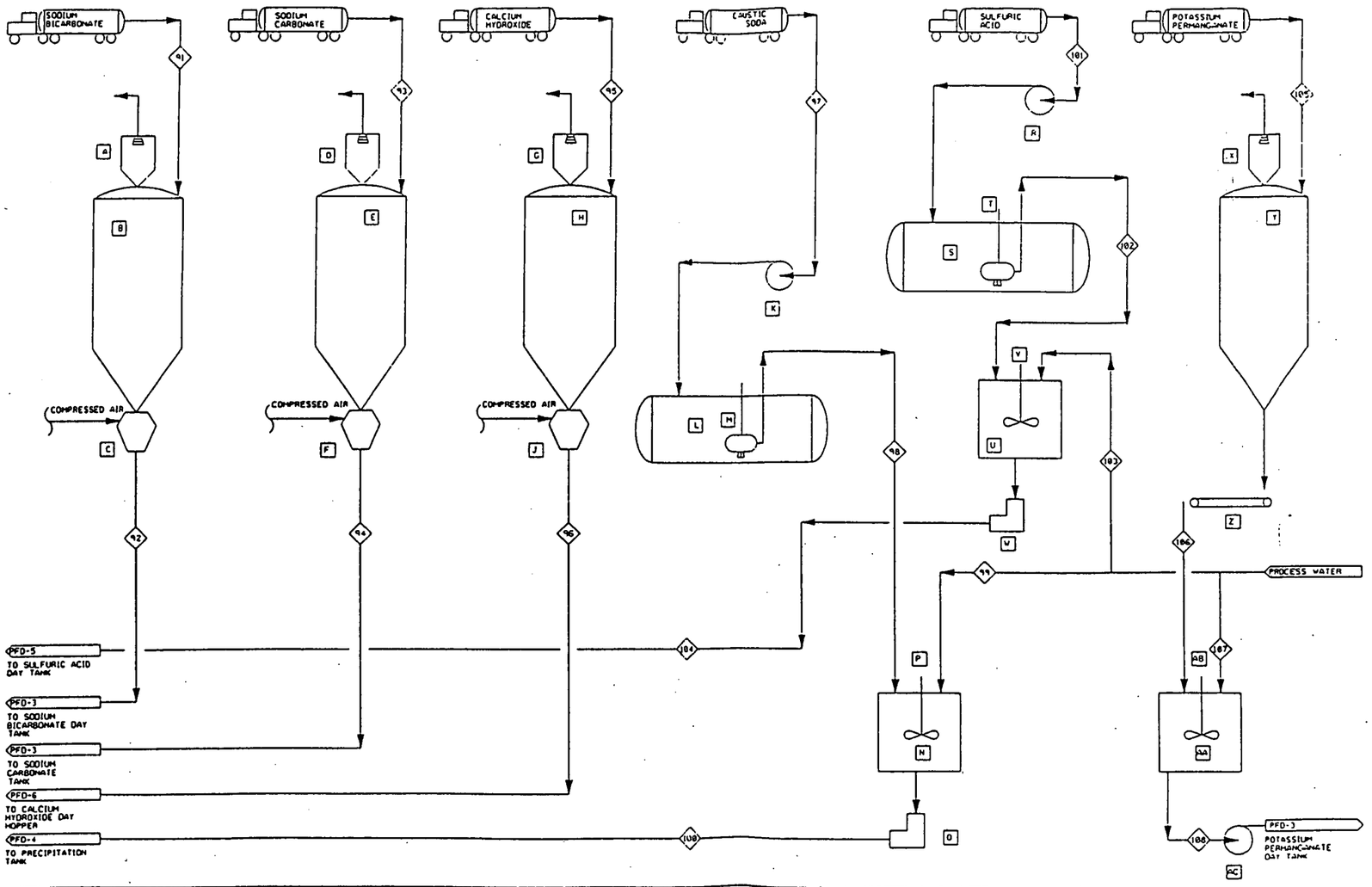

STREAM NO.	74	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
COMPONENT	CO2 TO RECARB TANK	NaHCO3 UNL'D TO STORAGE	NaHCO3 TO DAY TANK	Na2CO3 UNLOAD TO SILO	Na2CO3 TO DAY TANK	Ca(OH)2 UNL'D TO SILO	Ca(OH)2 TO LEACH	CAUSTIC UNL'D TO STORAGE	CAUSTIC TO MAKE-UP TANK	CAUSTIC MAKE-UP WATER	CAUSTIC TO PRECIP	SULFURIC UNLOAD	SULFURIC TO MAKE-UP	WATER TO SULF. MAKE-UP	SULFURIC TO LEACH	KMnO4 UNL'D TO STORAGE	KMnO4 TO DAY MIX TANK	GRNDWATR TO KMnO4 MIX TANK	KMnO4 TO DAY TANK
OPERATING TIME (hrs/day)	24	INTERMIT	INTERMIT	INTERMIT	INTERMIT	INTERMIT	INTERMIT	INTERMIT	INTERMIT	INTERMIT	24	INTERMIT	INTERMIT	INTERMIT	INTERMIT	INTERMIT	INTERMIT	INTERMIT	INTERMIT
SOLIDS (DRY) (lbs/hr)																			
MOISTURE (lbs/hr)																			
WATER (lbs/hr)											587.0								
SODIUM BICARBONATE (lbs/hr)																			
SODIUM CARBONATE (lbs/hr)																			
POTASSIUM PERMANGNATE (lbs/hr)																			
SODIUM HYDROXIDE (lbs/hr)											587.0								
STEAM (lbs/hr)																			
CARBON DIOXIDE (lbs/hr)	43.9																		
OTHER (lbs/hr)																			
PRECIPITATES (lbs/hr)																			
MASS FLOW (lbs/hr) (gpm)	43.9										1174.1 1.5								
% SOLIDS (BY WEIGHT)																			
SOLIDS PARTICULATE SIZE																			
SPECIFIC GRAVITY (SOLIDS)																			
SPECIFIC GRAVITY SLURRY/WATER											1.529								
TEMPERATURE (F)											68								
URANIUM (mg/kg)																			

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	1	SODIUM BICARBONATE BIN VENT FILTER
B	1	SODIUM BICARBONATE SILO
C	1	SODIUM BICARBONATE BLOW POT/LOAD CELLS
D	1	SODIUM CARBONATE BIN VENT FILTER
E	1	SODIUM CARBONATE SILO
F	1	SODIUM CARBONATE BLOW POT/LOAD CELLS
G	1	CALCIUM HYDROXIDE BIN VENT FILTER
H	1	CALCIUM HYDROXIDE SILO
J	1	CALCIUM HYDROXIDE BLOW POT/LOAD CELLS
K	2	CAUSTIC SODA UNLOADING PUMP
L	1	CAUSTIC SODA STORAGE TANK
M	2	CAUSTIC SODA SUPPLY PUMP
N	1	CAUSTIC SODA DAY TANK
P	1	CAUSTIC SODA DAY TANK AGITATOR
Q	2	CAUSTIC SODA METERING PUMP
R	2	SULFURIC ACID UNLOADING PUMP
S	1	SULFURIC ACID STORAGE TANK
T	2	SULFURIC ACID SUPPLY PUMP
U	1	SULFURIC ACID MAKE-UP TANK
V	1	SULFURIC ACID MAKE-UP TANK AGITATOR
W	2	SULFURIC ACID METERING PUMP
X	1	POTASSIUM PERMANGANATE BIN VENT FILTER
Y	1	POTASSIUM PERMANGANATE SILO
Z	1	POTASSIUM PERMANGANATE METERING CONVEYOR
AA	1	POTASSIUM PERMANGANATE MIX TANK
AB	1	POTASSIUM PERMANGANATE MIX TANK AGITATOR
AC	2	POTASSIUM PERMANGANATE SUPPLY PUMP
AD	-	CO2 CYLINDERS

LEGEND

MAIN PROCESS LINE

SECONDARY PROCESS LINE

FIGURE L.2-8. PROCESS FLOW DIAGRAM REAGENT RECEIPT AND HANDLING

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areas for off-loading liquid reagents from tanker trucks will be diked with sumps to control accidental releases.

L.2.2.8 Clean Soil and Waste Handling

Figures L.2-9 and L.2-10 provide process flow diagram and major equipment lists for clean/contaminated soil storage and packaging. These operations would receive material (filter cake) from the carbonate leach and precipitate filters, and the sulfuric acid leach and precipitate filters. The cake from these operations would be continuously loaded into B-25 boxes and/or sealand containers by the use of diverter gate assemblies and skid conveyors, wherein the containers being loaded are placed on roller skids and indexed periodically so the containers can be filled to their maximum capacity.

The cake from the carbonate leach filter (assumed as clean) would be packaged directly into B-25 boxes and/or sealand containers. These containers would be randomly sampled (approximately one in 10), and the samples sent to a testing lab to determine if the contents meet the established WACs. Containers would be staged on a concrete pad next to the packaging facility pending sampling results. After receipt of sampling results, containers whose contents meet the WACs would be retrieved from the staging pad by forklifts and directed to the "clean" storage area. The contents of the clean containers may be mixed with conditioning additives such as dry sand, topsoil, etc., if necessary, to increase the solids content so that the resulting mixture can be handled easily by conventional earth moving equipment. A conditioning and loading station would be provided to load the conditioned soil directly into trucks for consolidation or backfill.

However, the containers whose contents do not meet the PRLs would be directed to the contaminated soil storage pad before their transportation to one of two disposition scenarios: sulfuric acid leaching or stabilization. A portion of the contaminated soil is reslurried with water to form a 60 percent solids slurry and fed to the sulfuric acid leaching system. The sulfuric acid leaching system is designed to treat 1.7 dry tons per hour of soil; therefore, only the amount of contaminated soil required to meet this rate would be slurried. Any remaining contaminated soil over and above the 1.7 dry tons per hour would be stabilized, containerized, and shipped off site for disposal.

The cake from the sulfuric acid leach filter would be containerized and randomly sampled to determine whether the WACs are being met. Cake that meets the PRLs would be conditioned with sand, if necessary, and transported for consolidation or backfill. Cake that does not meet the WACs would be stabilized, containerized, and shipped off site for disposal.

The knowingly contaminated material (filter cake from the carbonate precipitation filter and sulfuric acid precipitation filter) would be stabilized, containerized, and shipped off site for disposal.

All containers would be lidded, monitored, and swiped for contamination on their outside surface. If required, the outside surface of the containers would be decontaminated. Containers would be

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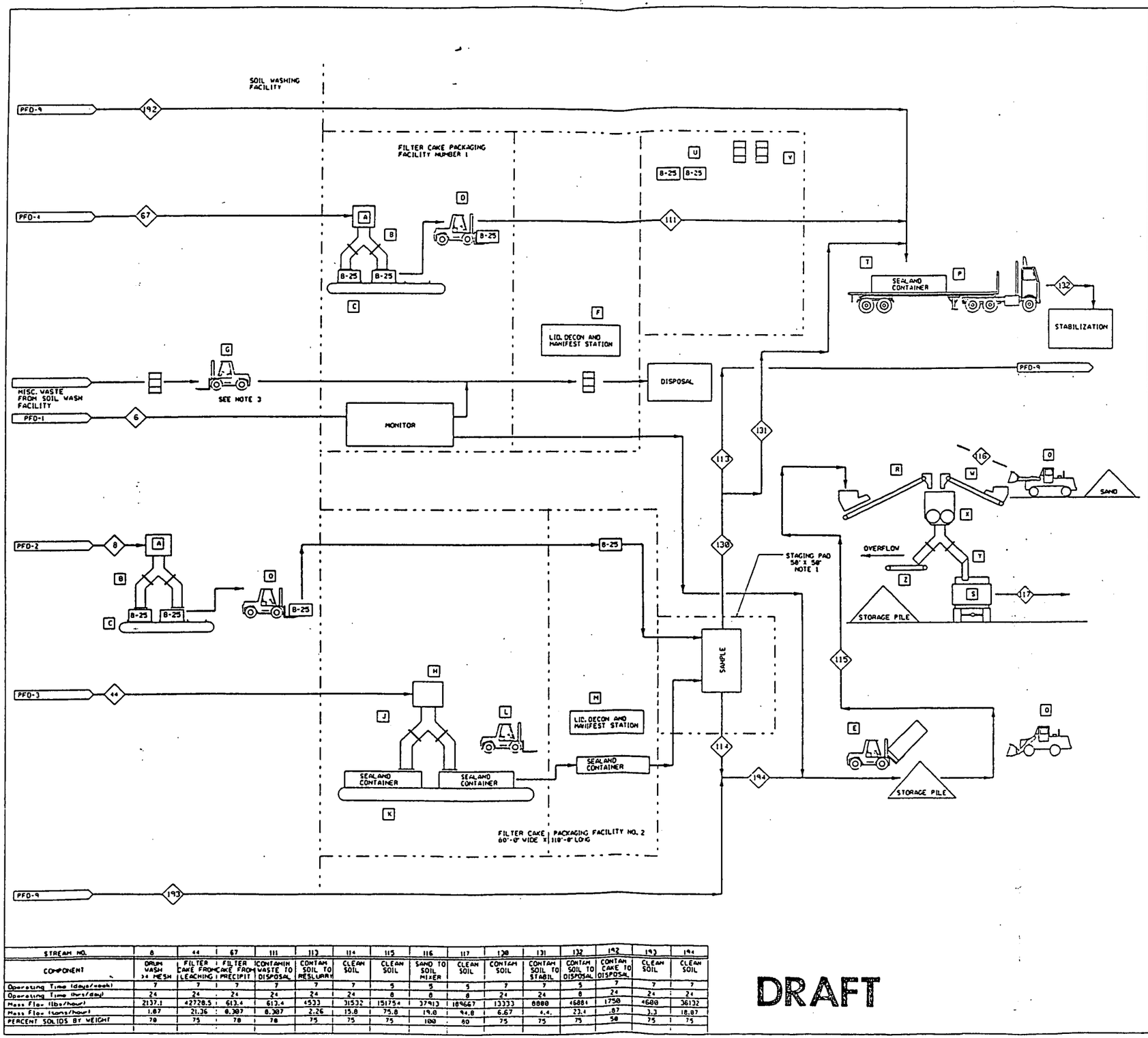

STREAM NO.	8	44	67	111	112	114	115	116	117	120	131	132	192	193	194
COMPONENT	DRUM WASH >6 MESH	FILTER CAKE FROM LEACHING	FILTER CAKE FROM PRECIPIT	CONTAMIN WASTE TO DISPOSAL	CONTAM SOIL TO RESLURRY	CLEAN SOIL	CLEAN SOIL	SAND TO SOIL MIXER	CLEAN SOIL	CONTAM SOIL	CONTAM SOIL TO STABIL	CONTAM SOIL TO DISPOSAL	CONTAM CAKE TO DISPOSAL	CLEAN SOIL	CLEAN SOIL
Operating Time (days/week)	7	7	7	7	7	7	5	5	5	7	7	5	7	7	7
Operating Time (hrs/day)	24	24	24	24	24	24	8	8	8	24	24	8	24	24	24
Mass Flow (lbs/hour)	2137.1	42728.5	613.4	613.4	4533	31532	151754	37913	189667	13333	8888	4688	1758	4688	36132
Mass Flow (tons/hour)	1.07	21.36	0.307	0.307	2.26	15.8	75.8	19.0	94.8	6.67	4.4	2.3	.87	2.3	18.07
PERCENT SOLIDS BY WEIGHT	70	75	70	70	75	75	75	100	80	75	75	75	50	75	75

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MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	2	LOADING HOPPER
B	2	DIVERTER GATE ASSEMBLY
C	2	SKID CONVEYOR
D	2	5 TON FORKLIFT (CONTAMINATED) W/DRUM GRAB
E	1	20 TON FORKLIFT W/DUMPING ATTACHMENT (CLEAN)
F	1	LID. DECON AND MANIFEST STATION
G	1	1 TON FORKLIFT W/DRUM GRAB
H	1	LOADING HOPPER
J	1	DIVERTER VALVE ASSEMBLY
K	1	HIGH CAPACITY SKID CONVEYOR
L	1	20 TON FORKLIFT (CONTAMINATED)
M	1	LID. DECON & MANIFEST STATION
P	2	FLAT BED TRUCK (40 TON CAPACITY)
O	2	TRACK LOADER
R	1	CONVEYOR
S	3	DUMP TRUCK
T	50	SEALAND CONTAINER
U	50	B-25 CONTAINER
V	10	DRUM (55-GAL)
W	1	CONVEYOR
X	1	AUGER MIXER
Y	1	DIVERTER CHUTE
Z	1	OVERFLOW CONVEYOR

LEGEND

MAIN PROCESS LINE

SECONDARY PROCESS LINE

NOTES:

1. STAGING AREA REQUIRED FOR STORAGE OF 8 HOURS OF PRODUCTION TO ACCOMODATE RESULTS OF SAMPLING TO DECIDE IF TREATED SOILS HAVE PASSED THE ACCEPTANCE CRITERIA.
2. DRUMS REQUIRED FOR MISCELLANEOUS SECONDARY WASTES, SUCH AS SPENT MEDIA AND CONTAMINATED RESIDUES.

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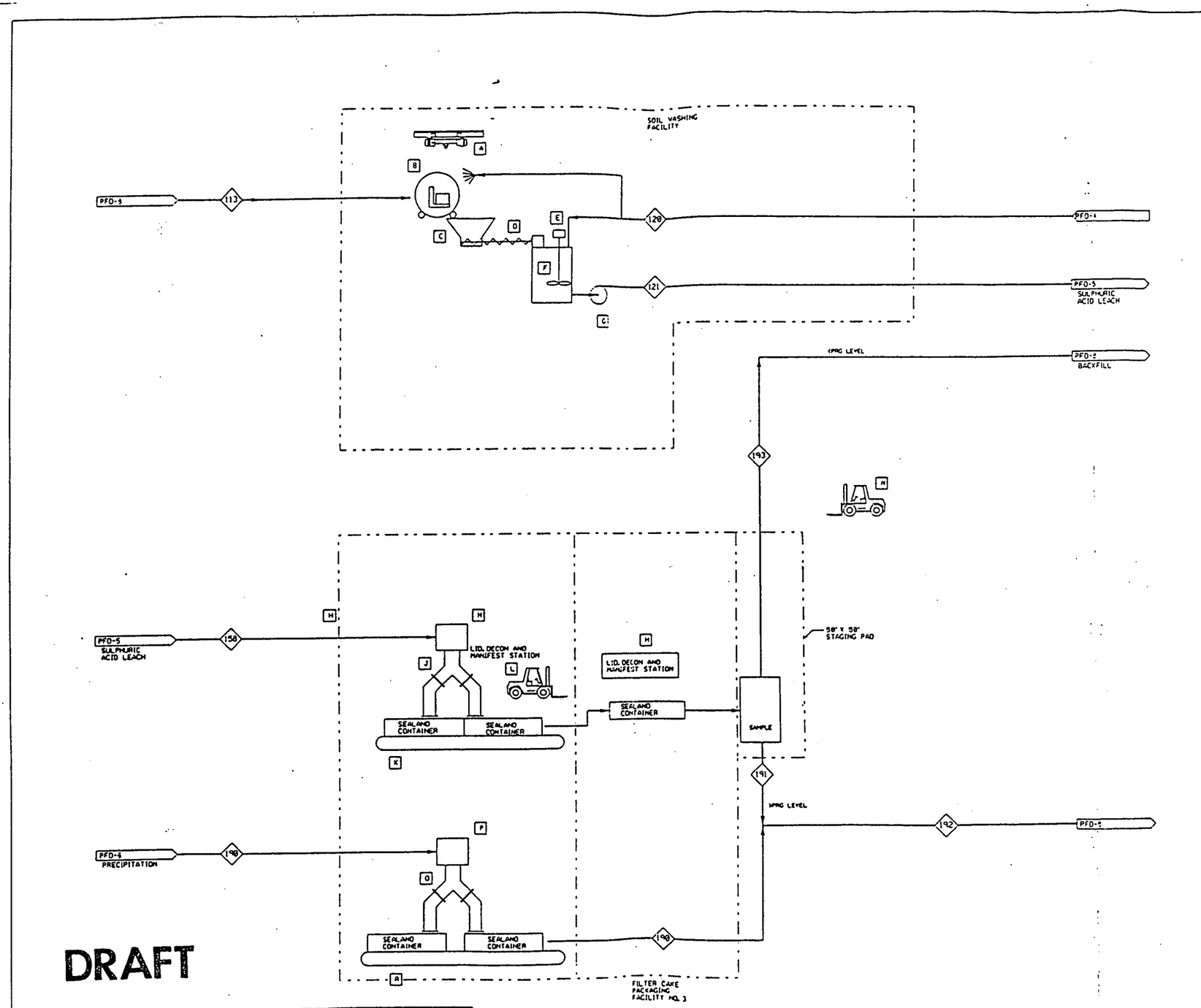
FIGURE L.2-9. PROCESS FLOW DIAGRAM
CLEAN/CONTAMINATED SOIL STORAGE



STREAM NO.	113	120	121	158	190	191	192	193
COMPONENT	CONT. SOIL TO RESLURRY	PROCESS WATER	SLURRY TO ACID LEACH	PRECIP FROM LEACH	CONTAM CAKE TO DISPOSAL	CONTAM CAKE	CONTAM CAKE TO DISPOSAL	CLEAN SOIL
Operating Time (days/week)	7	7	7	7	7	7	7	7
Operating Time (hrs/day)	24	24	24	24	24	24	24	24
Mass Flow (lbs/hour)	4533	1134.0	5667	4600	1750	0	1500	4600
Mass Flow (tons/hour)	2.27	0.57	2.83	2.30	0.87	0	0.750	2.3
Percent solids by weight	75	0	60	75	50	0	50	75

MAJOR EQUIPMENT LIST

MARK	QTY	EQUIPMENT NAME
A	1	BRIDGE CRANE
B	1	BOX DUMP
C	1	RECEIVING HOPPER
D	1	DOUBLE AUGER CONVEYOR
E	1	SOIL RESLURRY TANK AGITATOR
F	1	SOIL RESLURRY TANK
G	1	SOIL RESLURRY TANK PUMP
H	1	LOADING HOPPER
J	1	DIVERTER VALVE ASSEMBLY
K	1	HIGH CAPACITY SKID CONVEYOR
L	1	FORK LIFT - 20 TON CAPACITY, CONTAMINATED
M	1	LID DECON, MANIFEST STATION
N	1	20 TON FORKLIFT, CLEAN
P	1	LOADING HOPPER
Q	1	DIVERTER VALVE ASSEMBLY
R	1	HIGH CAPACITY SKID CONVEYOR

LEGEND

MAIN PROCESS LINE

SECONDARY PROCESS LINE

NOTES:

1. STAGING AREA REQUIRED FOR STORAGE OF 8 HOURS OF PRODUCTION TO ACCOMODATE RESULTS OF SAMPLING TO DECIDE IF TREATED SOILS HAVE PASSED THE ACCEPTANCE CRITERIA.
2. FOR EQUIPMENT ARRANGEMENT SEE DRAWING FIGURE 4-10 AND FIGURE 4-11.

FIGURE L.2-10. PFD-9 CLEAN/CONTAMINATED SOIL PACKAGING

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weighed while being filled. A manifest would be applied to each container to identify its contents and to track it to its subsequent treatment/storage/disposal site.

Forklifts would be used to handle and move containers during most of the above operations. Separate forklifts would be used in the clean and contaminated areas to preclude cross contamination of areas.

The B-25 boxes and sealand containers would be loaded onto a flatbed truck and transported to a treatment facility. Containers would be unloaded, washed, decontaminated, and returned to the flatbed truck for transportation back to the interim storage pad. Forklifts would be used for loading and off-loading of flatbed trucks.

In addition to waste soil, soil washing would also produce process wastewater. Process wastewater would be recycled back to the soil washing process to the greatest extent possible. The wastewater that cannot be recycled would be transferred to the AWWT facility for treatment.

Soil washing with sulfuric acid would also produce some waste sludge that requires further treatment. This sludge would be stabilized, containerized, and shipped off site for disposal.

L.2.3 MONITORING, MAINTENANCE, AND INSTITUTIONAL REQUIREMENTS

The soil washing facilities would be decontaminated and demolished once the processing of the soil was completed. Accordingly, no long-term monitoring, maintenance, or institutional controls would be applicable following the cessation of operations. During operations, air monitoring would be required to ensure that the engineered controls for material handling before, during, and after the treatment processes were functioning as designed. Operational maintenance of process equipment and facilities would be performed as required. The performance of the system would be monitored to ensure that WACs were continually achieved. Additional enhancements or reworking of the treated soil might be needed, so provisions would be made during detailed design to perform further bench-scale and pilot-scale treatability testing to optimize performance. The following sections discuss air emissions control and system performance considerations.

L.2.3.1 Air Emissions

Through the entire soil washing operation source emissions, including airborne chemicals, particulates, and gases (if any), would be controlled to meet regulatory requirements.

Open transfer of soil (i.e., soil dumping stations, conveyors, etc.,) would be provided with either ventilation equipment or dust suppression equipment. In addition, a ventilation system would be provided as part of the enclosed process building.

All process tanks storing or handling contaminated soil would be enclosed and vented, with the vents routed to a scrubber to remove particulates, fumes, and gases before release to the environment. The sulfuric acid reactor scrubbers (also enclosed and vented) contain sulfuric acid greatly diluted by

water and other reagents. Therefore, release of sulfuric acid vapors is not anticipated. Compliance with the National Emissions Standards for Hazardous Air Pollutants would be addressed after further test results verify what (if any) emissions are produced during the soil washing process.

The dry reagent storage silos would be equipped with bin vent filters for dust collection, thereby eliminating dust releases from these sources.

L.2.3.2 System Performance Considerations

Ultimately, the performance of the soil washing system would be determined by its ability to reduce the mass and mobility of the contaminants to levels that meet established WACs. If the treated soil does not meet established WACs, it may be necessary to rework it. The quantity of soil reworking would correspondingly impact the processing rate of excavated contaminated soil. Additional bench-scale and pilot-scale treatability testing would be performed before design of the soil washing system to establish the system performance requirements.

Some FEMP soil contaminants may exhibit high leachability before or after treatment. As a result, it may be necessary to bind up the contaminants through an additional process operation to meet WACs. The addition of phosphate to reduce contaminant mobility is currently being studied. If the selected remedial alternative includes soil washing, further bench-scale testing would be performed to ensure that phosphate addition provides the desired results.

It is envisioned that additional process steps to accommodate above requirements would include conditioning with diluted phosphoric acid to stabilize residual uranium in the treated soil. This operation may be performed in an agitated conditioning tank. It is likely that this equipment would be placed ahead of the solid/liquid separation (filtration) step for the treated soil slurry. Conditioning would be accomplished (pending testing verification) by adding phosphoric acid to the slurry in order to lower the pH from 10 to 5. Diluted phosphoric acid would be supplied by a day tank and metered to the process at a controlled rate to maintain the desired pH level.

As an alternative, conditioning may be accomplished by rinsing the filter cake during filtration with diluted phosphoric acid before discharge, eliminating the need for a conditioning tank (pending testing verification). In the event that multiple-stage drum filters are selected over horizontal belt filters during the final system design, this acid rinsing may be accomplished in the repulping step before the final stage filter.

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L.3.0 OFF-SITE DISPOSAL

The off-site disposal component includes the staging, loading, transportation, and disposal of contaminated soil/sediment, dewatered wastewater treatment sludges, solidified wastewater treatment resins, dewatered and/or cement stabilized soil washing treatment residuals, and miscellaneous debris generated during the decontamination and dismantlement of remedial facilities. Off-site disposal is associated to some degree with each remedial alternative and land use objective, except the no-action alternative. On the basis of cost analyses completed by the FEMP on similar volumes and types of waste streams in the Operable Unit 1 FS, the representative off-site disposal facilities selected for alternative evaluation in this FS include a permitted commercial disposal facility located near Clive, Utah, and the Department of Energy's Nevada Test Site (NTS).

Cost and implementability information used in the detailed analysis of alternatives was based upon use of these off-site facilities. Recognizing that remedial activities for Operable Unit 5 soil and sediment are projected to take 22 years and wastewater treatment sludges may be generated over a 70-year period, transportation and WACs may be altered considerably over such a time frame. Such uncertainty was factored into risk budget analysis for alternatives relying on off-site disposal. Appendix E presents an analysis of the WACs for the permitted commercial disposal facility and NTS in relation to the types of waste streams envisioned to be generated by Operable Unit 5 remedial activities.

Contaminated soil and sediment shipped to either the permitted commercial disposal facility or the NTS would not be treated or stabilized before disposal. The exception to this is soil containing RCRA constituents exceeding LDR levels, soil containing PCBs exceeding solid waste disposal requirements, and soil found to contain large quantities of petroleum products from underground storage tank removals. This soil would be treated by mobile treatment units as described in the excavation component, Section L.1.0.

As described in Appendix E, the representative permitted commercial disposal facility accepts hazardous, low-level radioactive, and mixed wastes in bulk or containerized form. The facility accepts bulk rail shipments, bulk highway shipments, 20 cubic yard (yd^3) boxes, B-25 boxes (3.5 yd^3), drums, and smaller containers. Containers are not placed in the commercial facility's disposal cells, but are emptied and returned to the generator for future use. The NTS has stricter WACs because only containerized material is accepted for disposal.

As described in Appendix E, both off-site disposal facilities limit the moisture content (free liquids) of wastes. NTS requires that free liquid not exceed 0.5 percent of the waste volume. Use of Method 9095 (Paint Filter Test - EPA Publication SW-846) may be required to demonstrate compliance with

this acceptance criteria. Wastewater treatment sludges and residues may be dewatered or dried before shipment. Absorbent may be added to contaminated soil/sediment to the extent required to ensure WACs are attained.

For contaminated soil and sediment quantities totalling greater than 50,000 cubic yards, 100-ton capacity gondola rail cars would be used for shipment of material to the disposal facility. Stabilized materials would be sized to meet WACs and loaded into gondola or boxcars and shipped to the disposal site. Contaminated debris would be size-reduced to meet WACs and loaded into 20-ton containers, with the containers placed on flatbed rail cars. The approximate distance by rail to the representative commercial disposal facility is 1900 miles.

Contaminated soil and sediment quantities of 50,000 yd^3 or less would be transported from the excavation site to the central storage facility (CSF) by dump truck. Material would be stored until sufficient quantities are accumulated to package and ship off site by truck.

Figure L-3.1 presents a flow diagram of the activities involved in the off-site disposal of contaminated soil, sediment and waste material. The activities associated with off-site disposal are described in the following sections.

L.3.1 STAGING FACILITY FOR OFF-SITE SHIPMENT

For soil quantities greater than 50,000 yd^3 requiring off-site disposal, a staging facility would be constructed for interim storage and loading of materials. The staging facility would be located in the southwest quadrant of the FEMP, adjacent to the existing AWWT facility. A rail spur would be installed at this location for the parking of up to 50 rail cars.

L.3.1.1 Staging Bulk Soil/Sediments

The staging facility would be divided into active and backup soil storage stockpiles. The active stockpile would serve as the primary feed source for daily loading operations. The backup stockpile would store excess materials over and above the daily operational requirements and supply materials for loading during inclement weather.

Stockpiled soil would be transferred by a hydraulic excavator to the feeding hopper of a vibrating grizzly. Any soil size over 6 inches would be screened off into a container for size reduction in a shear shredder. Shredded material would be recycled to the feeding hopper for subsequent loading into a rail car. The undersize soil from the grizzly would be directed to a hopper equipped with an apron feeder at the discharge end. The apron feeder would transfer soil sized below 6 inches to a shuttle or belt conveyor for transfer to soil storage silos. The entire conveyor system would be enclosed, as necessary, to control any potential dust and isolate the contaminated soil from the

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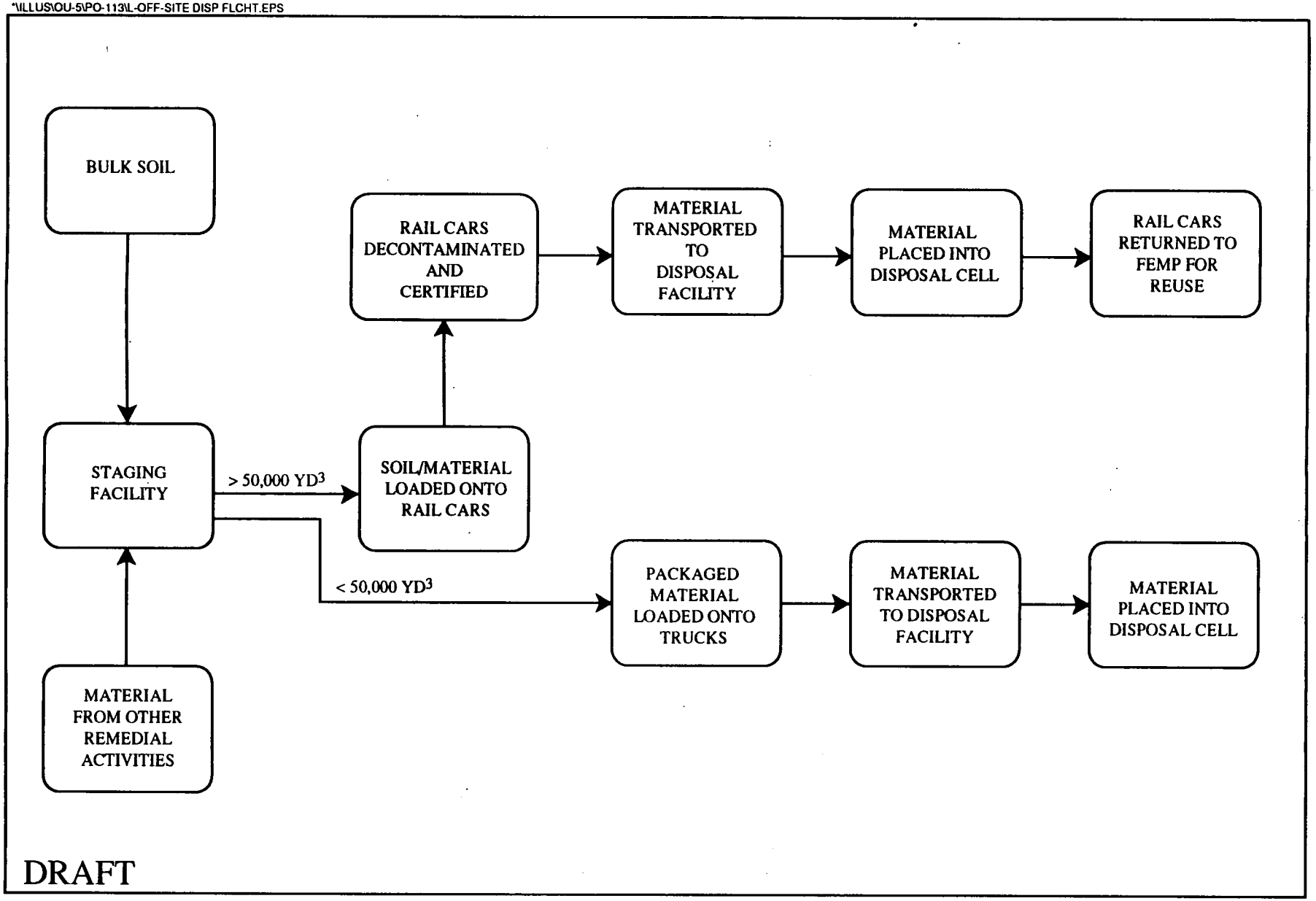

FIGURE L.3-1. OFF-SITE DISPOSAL FLOW DIAGRAM

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environment. Negative air pressure would be maintained within the enclosure to prevent emissions. Ventilation for the transfer system and storage silo would be provided by a high efficiency cartridge type dust collection system to minimize the emission of air particulates to the atmosphere. The storage silos would be elevated and located adjacent to the new rail siding for direct load-out to the rail cars.

L.3.1.2 Staging Other Contaminated Materials

Cement stabilized materials would be staged on covered pads adjacent to the staging facility. Contaminated debris would be staged at the CSF. Blocks of stabilized materials would be shrink wrapped or sprayed with a surface coating (e.g., epoxy paint) to minimize the potential for the spread of surface contamination. Contaminated debris would be sized to meet WACs and loaded into 20-ton containers.

L.3.2 CENTRAL STORAGE FACILITY

The CSF would be used for staging and packaging contaminated soil quantities less than 50,000 yd^3 requiring off-site shipment. The CSF is described in Section L.11.0.

L.3.3 LOADING RAIL CARS

Storage for up to 50 rail cars would be provided on the FEMP property on a newly constructed rail spur. Movement of individual cars from the staging area to loading and decontamination areas would be accomplished by the use of a car ejector, rail car puller, car retarder, and rail stops. A track mobile would move empty and full rail cars on the FEMP site. It is presently envisioned that one day's production capacity of rail cars would be staged at the loading area.

Disposable reinforced polyethylene liners would be placed in the empty gondola rail cars just before soil load-out at the FEMP. The liners would also incorporate a lapover top which is pulled outside the covers. Rail car covers meeting US Department of Transporation (DOT) packaging requirements would be used to enclose soil in the car. Polyethylene covers could also be employed to meet DOE packaging requirements.

A rail car dust collection hood would be incorporated with the silo discharge system to minimize air emissions during loading. As the rail car is moved into position, the hood would be lowered to seal with the rail car. The silo discharge would have multiple discharge spouts to enable uniform placement of the soil in the rail cars. Once the rail car is filled, the covers would be installed. Covers would be secured with clamps and locks to minimize the potential for tampering. The typical gondola car is approximately 45 feet long with a 100-ton weight capacity. Drying agents would be added to the vibrating grizzly and/or placed on the gondola car bed to ensure off-site disposal WACs are attained.

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Stabilized materials would be loaded by forklift onto boxcars for shipment to the off-site disposal site. The loaded 20-ton containers would be loaded onto flatbed rail cars by a forklift.

L.3.4 LOADING TRUCKS

Containers destined for disposal at the NTS would be loaded by forklift onto flat-bed trucks for transport. Containers must be certified for transport (e.g., surface contamination removed to acceptable levels) before placement on the truck. A maximum of five containers would be loaded onto a single flat-bed truck.

L.3.5 DECONTAMINATING AND CERTIFYING RAIL CARS

Bulk shipments of radioactive material are regulated by 49 CFR § 173.425 (c). The average estimated radioactivity concentration cannot exceed 0.001 millicurie per gram of material. External radiation levels on the rail cars cannot exceed 200 millirem per hour at any point on the external surface of the car. DOT regulations also establish the maximum allowable removable and fixed contamination on the external surfaces of the shipping container. Filled cars would be moved to a decontamination area to ensure DOT surface and direct radiation transportation levels are attained before release of the car from the facility. The decontamination area would be equipped with spray washing, monitoring devices, and other equipment as required to decontaminate the rail car and complete the shipment certification process. Upon completion of certification, the filled rail car would be moved to a staging area by a car ejector and retained in its position with a car retarder. Once a sufficient number of cars have been filled and certified for transport, the cars would be transported to the off-site disposal facility.

L.3.6 OFF-SITE TRANSPORTATION AND DISPOSAL

Filled gondola cars would be taken to a rail car rollover at the representative permitted commercial disposal facility, located off the Union Pacific Rail Road main line. The rollover is capable of unloading 10,000 yd^3 of waste per day. Before the gondola is overturned, the cover would be removed. The contents of the car would then be emptied and moved to the disposal cell. It should be noted that the disposal facility does not currently have the capability to remove the gondola car covers. Discussions with the representative disposal facility indicate that this capability could be readily added at the facility. The spent liner would be disposed of along with the waste. Stabilized blocks would be unloaded from the boxcars by forklifts and placed into the disposal cell. Containers would be unloaded from rail cars by forklifts or a gantry crane. The containers would be emptied and returned to the FEMP.

The number of trains, train size, and shipping frequency would be based on the volumes associated with the individual alternative and are based upon an estimated maximum 30-day round trip travel time from the site to the representative commercial disposal facility. Mileage to the off-site disposal

facility for the preferred route through East St. Louis, Illinois, is estimated at 1913 miles with two railroad companies involved. An alternate route through Chicago is slightly longer (1937 miles) but involves three railroad companies.

For scenarios where packaged material would be shipped off site by truck, the mileage is assumed to be 2065 miles. According to the Operable Unit 1 Treated Material Transportation Report, Supporting Report 4.0, for 2 yd^3 containers, the cost of the container, packaging and transportation is $643 per yd^3. Burial cost is assumed to be $10 per ft^3. Therefore, the total cost is assumed to be $918 per yd^3.

Trucks would be unloaded by forklift using disposal facility personnel. Containers would then be placed in the disposal cell.

L.3.7 RETURNING RAIL CARS

Following the unloading of the materials, gondola cars would be decontaminated to the extent necessary, covered, and returned to the FEMP. It is envisioned that only the exterior surface of the gondola car would require decontamination before release from the facility.

L.3.8 RETURNING TRUCKS

Following the unloading of containers, trucks would return to the FEMP.

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L.4.0 STABILIZATION

This section presents a description of the cement stabilization component. Cement stabilization is employed to stabilize soil, wastewater treatment sludges, and/or soil decontamination treatment wastes. The cement stabilization process involves mixing the contaminated materials directly with portland cement, flyash, water, and additives to control setting. The materials are transformed into the rigid matrix of the hardened concrete. The method physically solidifies the materials, with a standing monolithic solid as the end product. Cement stabilization is effective at immobilizing metals, such as uranium, because at the ph of the cement mixture, most multivalent cations are converted into insoluble hydroxides.

Cement stabilization is a widely used technology for treatment of predominately inorganic waste materials and has been commonly applied to the solidification of low-level radioactive wastes.

Extensive treatability testing was conducted by the FEMP to evaluate the viability of using cement stabilization as a support technology to address Operable Unit 1 waste materials. This testing focused on stabilizing the contents of the waste pits. The FEMP waste pits contain a heterogeneous matrix of sludge, soil, and miscellaneous debris containing high concentrations of uranium, other radioactive metals, inorganic compounds, and, to a lesser extent, organic compounds. These treatability test results for Operable Unit 1 have been used in this study to guide the development and evaluation of the cement stabilization process for its potential application to address soil and treatment sludges as part of Operable Unit 5 remedial alternatives. The Operable Unit 5 material to which this technology may be applied represent a more homogeneous waste type with generally much lower contaminant concentrations of uranium and other inorganic metals. In general, the treatability study testing conducted to support Operable Unit 1 concluded that cement stabilization was effective in controlling the leachability of uranium and other heavy metals. The testing further concluded that the solidified waste materials passed defined tests for durability (wet/dry and freeze/thaw) and showed low permeabilities. If cement stabilization is employed as a support technology to the selected Operable Unit 5 remedy, additional testing would be conducted during remedial design to refine proposed formulations and develop operational data. Careful formulation and quality control is required for the successful application of the stabilization process.

Following stabilization, the cement stabilized materials would be shipped off site, placed in an on-property disposal cell, or placed within a consolidation area and covered with a multilayered cap. Each of these options is discussed in other component descriptions in this appendix. The type and quantity of material requiring stabilization are discussed within the description of each of the remedial alternatives.

L.4.1 DESIGN CONSIDERATIONS

The conceptual design of the cement stabilization system selected to support the development and evaluation of remedial alternatives includes the following design considerations:

- Consistently attain performance-based WACs for the on-property or off-site disposal facility, including leachability and durability
- Minimize, to the extent practical, the addition of cement and other noncontaminated materials to reduce disposal capacity requirements
- Provide for soil blending systems to optimize product consistency
- Provide for product inspection and quality assurance to ensure performance requirements have been attained before disposal
- Provide capability to recycle off-specification product

The FEMP does not envision the construction of a cement stabilization facility for remedial alternatives which rely upon cement stabilization only as a support technology for addressing relatively small quantities of spent wastewater treatment media, regenerate sludge, and soil exhibiting inorganic constituents greater than TCLP concentrations. For these alternatives, it is assumed that a vendor-operated stabilization service would be employed, on an as-needed basis, to cement stabilize stored materials. However, the bulk soil stabilization facility will include flexibility to treat various sludges, spent media, and soil decontamination wastes. Adequate storage capacity would be provided at the AWWT facility and CSF (i.e., for soil exhibiting characteristics of a hazardous waste) to stage materials for stabilization through the vendor-supplied service.

L.4.2 GROUT FORMULATION

The grout formulation presented in Table L.4-1 was used as the technical basis for developing remedial alternative cost estimates. The formulation was developed on the basis of available data from the Operable Unit 1 treatability study and examination of literature data. The grout formulation was considered generally applicable to soil and dewatered wastewater treatment and soil decontamination sludges. Final grout formulations would be selected on the basis of process design testing conducted following remedy selection.

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TABLE L.4-1

GROUT FORMULATION

Ingredient	Percentage by Weight	Tons/Ton of Dry Soil
Dry Soil	40.8	1.0
Water	24.5	0.6
Cement	24.5	0.6
Fly Ash	10.2	0.25
Other	Minimal	Minimal

L.4.3 COMPONENT DESIGN

Upon consideration of the listed design requirements and the selected grout formulation, the stabilization flow diagram depicted in Figure L.4-1 was compiled as the conceptual basis for this study. Final process flow diagrams would be completed as part of remedial design. As identified in the figure, the cement stabilization component is comprised of the following unit operations:

- Soil staging and preparation
- Reagent receipt, storage, and blending
- Grout mixing
- Product handling and curing.

The following sections provide descriptions of each of these unit operations.

L.4.4 SOIL STAGING AND PREPARATION

An incoming soil storage facility would be provided for staging contaminated soil destined for cement stabilization. The soil storage facility would be divided into active and backup soil stockpiles. The active soil stockpile would provide feed materials for the cement stabilization process. The backup soil stockpile would stage excess soil over and above the daily processing requirements and would supply material to the cement stabilization facility during inclement weather. Excavated soil would be received at the incoming soil storage facility in 40-ton roll-off containers. The containers would be dumped to the backup soil stockpile. A track loader would transfer soil from the backup soil stockpile to the active soil stockpile.

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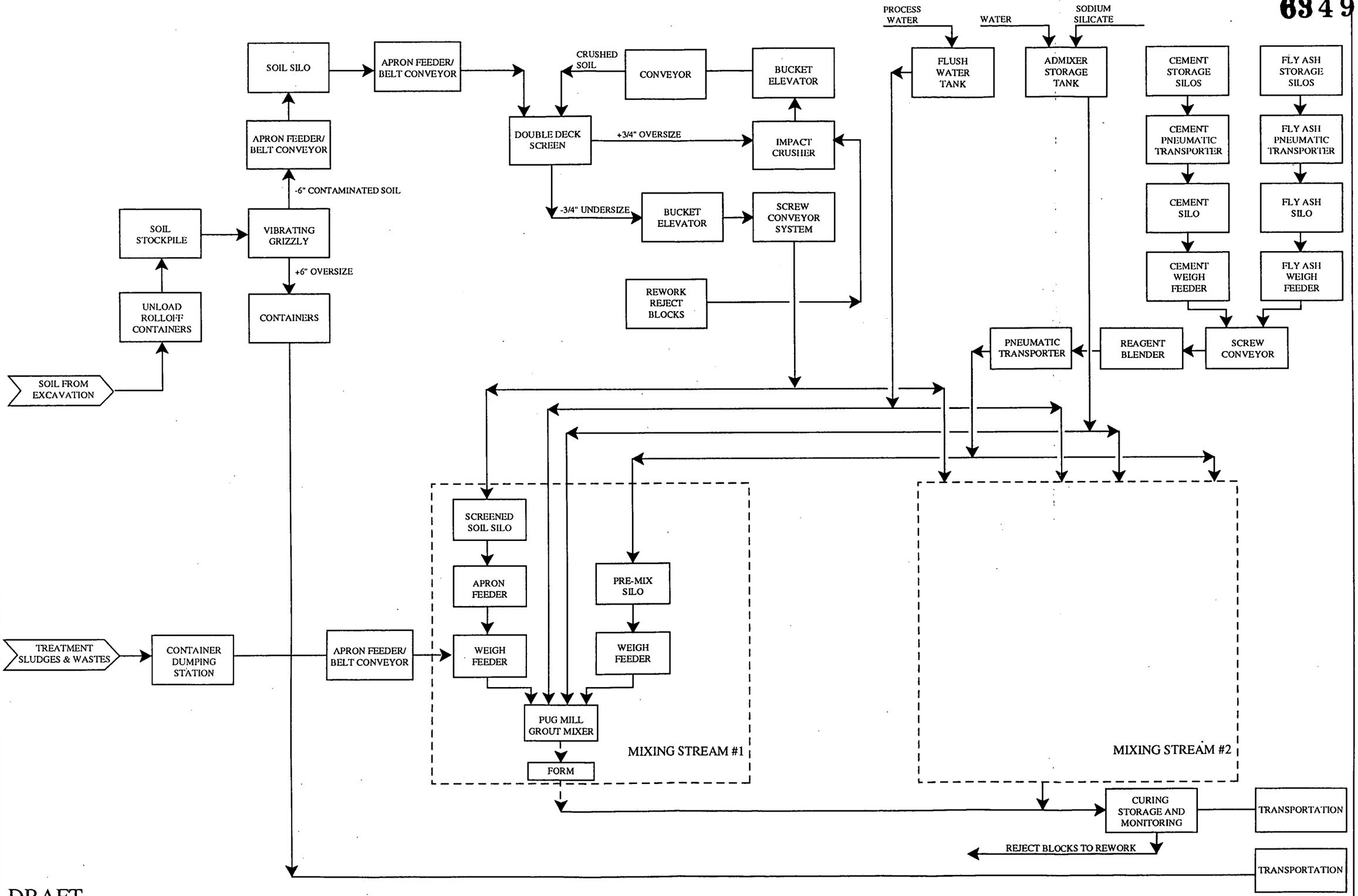

\ILLUS\OU-5\PO-113\SOIL STAB BFD.EPS

FIGURE L.4-1. SOIL STABILIZATION PROCESS FLOW DIAGRAM

A hydraulic excavator would transfer soil from the active soil stockpile to the feeding hopper of a vibrating grizzly. Any materials over 6 inches would be screened off into a container which would be transferred to a storage area for transfer to an on-property disposal facility. The undersize (less than 6 inches) soil would be directed to a hopper equipped with an apron feeder at the discharge end. The apron feeder would transfer soil sizes below 6 inches to a shuttle or belt conveyor for transfer to the double deck screen in the cement stabilization facility.

The oversized (3/4-inch to 6-inch) soil from the double deck screen would be fed to an impact crusher, which operates in a closed circuit with the double deck screen. Materials smaller than 3/4 inch would be picked up by a bucket elevator and conveyed by screw conveyors to soil storage silos.

Dewatered wastewater treatment sludges and soil decontamination wastes requiring cement stabilization would be transferred, through a container dumping station, to the apron feeder for mixing in the pug mill. Adequate container storage areas would be provided at the cement stabilization facility to stage treatment residuals before stabilization.

L.4.4.1 Reagent Receipt, Storage and Blending

The cement stabilization process requires a large supply of cement and flyash. The existing FEMP railroad spur would be extended to serve this facility. Reagents would be transferred directly from rail cars to storage silos. Each storage silo would have a pneumatic transfer system for moving material from the storage silos to weigh feeders so it could be metered out in a controlled ratio into premix blenders. A pneumatic solids-handling system would then transfer the premix to a storage silo located above the grout mixers. The silos, transfer area/premix blender, and the premix silos would be equipped with a dust collection system to minimize atmospheric releases.

L.4.4.2 Grout Mixing

Contaminated soil and treatment sludges/wastes requiring stabilization would be fed to grout mixers at the rates specified in the final mix designs. Two mixing lines are anticipated to support cement stabilization to ensure continuity of operation. Continuous mixers such as pug mills would be used as grout mixers. Grout additives, such as sodium silicate, would be used, as necessary, to control the setting of the grout. The sodium silicate would be added to the soil or sludges at the inlet end of the grout mixer. Premix and soil or sludge would be metered (by continuous weigh feeders) into the grout mixers. The grout would be discharged directly into forms for setting and curing. A flush water system would be provided to flush out the grout transfer chutes and mixing equipment whenever equipment is shut down. All equipment would be located in a containment area with spillage being recovered and recycled through the process.

L.4.4.3 Product Handling and Curing

The grout would be discharged into forms for solidification. A conveyor system would be used to position empty forms under the discharge chute from the pug mill. The forms would be filled with a weighed amount of the soil-bearing grout. The forms would be vibrated to ensure even filling. The conveyor would then move the full forms out and replace them with empty ones. A forklift would supply the feed end of the conveyor with empty forms and transport full forms into the staging area for curing, testing, and inspection. An estimated 48 hours of initial curing is anticipated before stripping the forms. If a form's contents do not meet product specifications, it would be transported to the crushing and screening area and reprocessed through the system.

The concrete blocks which meet specifications would be lifted onto flatbed trucks for transport to an on-property disposal facility.

L.4.5 PROCESS EMISSIONS

The cement stabilization process is not envisioned to generate secondary solid waste streams. Liquid effluent from the process will be minimal. Generated wastewaters would be transferred to the AWWT facility for treatment.

The stabilization process is anticipated to generate particulate emissions from the handling and storage of contaminated soil, cement, and flyash. Additionally, dusts would be generated during crushing and screening operations involving the soil debris and off-specification product. Dust collection systems would be provided to minimize particulate emissions to the atmosphere. Additionally, the process buildings would be equipped with HEPA filters to control fugitive emissions from the facility ventilation systems to the environment. All silos storing contaminated soil or dry reagents would be equipped with bin vent filters for dust collection, thereby eliminating dust releases from these sources. Compliance with the National Emissions Standards for Hazardous Air Pollutants would be addressed after further test results verify what (if any) emissions are produced during the stabilization process.

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L.5.0 CONSOLIDATION

This component involves delineating and preparing an on-property area to receive untreated, treated, or stabilized soil excavated either from other parts of the FEMP property or from off-property locations. Soil meeting the WACs established for consolidation would be accumulated in a single area to minimize the amount of FEMP property surface acreage affected by contaminated soil. The consolidated material would be covered either by topsoil (earthen cover) or by a multilayered cap, depending upon the WACs. This would preclude the potential for direct contact, incidental ingestion/inhalation, or direct radiation exposure. For consolidation under the earthen cover, the WACs provide for protection of the Great Miami Aquifer, because the earthen cover is not assumed to reduce the infiltration rate over that of native soil. The earthen cover would reduce the migration of contaminants to air and surface water. Consolidation under the multilayered cap would reduce the migration of contaminants to air, surface water and groundwater, achieving protectiveness of the Great Miami Aquifer.

The consolidation component is included as a support technology for the detailed analysis of remedial alternatives evaluated under Land Use Objectives 2 and 3. The rationale employed for siting the consolidation area is consistent with the overall goal of these objectives, to minimize the FEMP property areas for which institutional controls would be required to restrict future land use. Several portions of the FEMP have been eliminated from siting consideration. The western portion of the site, including areas associated with Operable Units 1 and 4, would not be considered because of its proximity to Paddys Run and the floodplain. Eastern and southeastern portions of the FEMP property would be suitable from a geologic standpoint, but are currently the least contaminated areas on the property. In the interest of maximizing the potential release of areas from use restrictions, these portions were not considered solely for the consolidation location. Because it is unlikely, under Land Use Objectives 2 and 3, that any portion of the former production area would be released for some unrestricted or restricted use, the northern portion of the area was selected to support material consolidation. For those remedial alternatives considering both a consolidation area component and an on-property disposal cell or the installation of a multilayered cap component, excavated soil attaining the WACs for consolidation with earthen cover would be used to the extent possible in the construction of the fill dikes within the disposal cell or cap. Excess soil for consolidation with an earthen cover would be constructed around the disposal cell to create a buffer of less contaminated materials.

Through fate and transport modeling, WACs have been developed for the materials that would be placed in the consolidation area. Different sets of criteria have been developed for consolidation under the earthen cover or the multilayered cap. Materials whose characteristics will be compared to the criteria include untreated contaminated soil, treated contaminated soil with residual contamination,

and stabilized contaminated soil. The WACs are based on conservative fate and transport modeling assumptions, including the geologic conditions underneath the proposed consolidation area location.

Since the former production area contains some of the most heavily contaminated soil on the FEMP property, portions of this area would be extensively excavated, regraded, and backfilled to the extent required during the implementation of those remedial alternatives adopting the consolidation component. The excavations would involve removing both contaminated soil and perched groundwater zones. This would result in the removal of higher permeability soil as part of the contaminated materials excavation. Excavated soil would be replaced by clean, compacted fill having a permeability at least equivalent to that of the gray clay.

The multilayered cap over the consolidation area would be designed without incorporating or relying upon the geologic characteristics of the existing, or subsequently emplaced, soil underlying the consolidated materials. For fate and transport modeling purposes, the upper brown clay layer of the glacial overburden is assumed to be absent. The WACs for placing materials under the cap incorporate the infiltration rate through the cap, the assumed absence of the brown clay layer, and a minimum thickness of 20 feet of gray clay or equivalent backfilled compacted soil. The WACs for placing material under the earthen cover incorporate an infiltration rate equivalent to native soil and treat the brown and gray clay layers the same as described for the cap. WACs are discussed in more detail in Section 4.0 and Appendix F.

The size of the consolidation area would be dependent on the volume of soil meeting the WACs for the selected remedial alternative. The approximate dimensions of the consolidation areas are provided as part of the detailed description of each remedial alternatives. The footprint of the consolidation area would require perpetual federal ownership, a groundwater monitoring system, restrictions within the property deed, permanent land markers, and a performance review of the continued protectiveness of the consolidation area at least once every five years.

L.5.1 DESIGN CONSIDERATIONS

The conceptual design of the consolidation area selected to support the development and evaluation of remedial alternatives includes the following design considerations:

- Reduce/minimize rainwater infiltration through the use of a compacted soil/vegetative layer cover or multilayered cap. The infiltration rate through the earthen cover would be 6 inches per year, the same as native soil. The infiltration rate through the cap would be approximately 0.9 inch per year.

- Prevent earthen cover degradation caused by such mechanical forces as the freezing/thawing cycle.

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- Minimize erosion and promote evapotranspiration through the use of a vegetative cover.
- Prevent storm water erosion through grading and drainage ditch construction.
- Accommodate construction of the consolidation area in phases to sequence construction activities with the soil remediation schedule and with the remediation activities of other operable units.
- Minimize the potential for settlement through compaction of the consolidated soil.
- Minimize the need for long-term surveillance and maintenance.
- Provide for deed restrictions and monuments identifying the consolidation area to preclude the potential for human intrusion.

Upon consideration of the above, the consolidation area configurations depicted in Figures L.5-1 and L.5-2 were selected as the conceptual basis for the detailed analysis of alternatives. Figure L.5-1 depicts a cross-section of a consolidation area with an earthen cover. Figure L.5-2 depicts a cross-section of a consolidation area with a multilayer cap.

L.5.2 CONSOLIDATION AREA CONSTRUCTION

L.5.2.1 Site Preparation

Construction of the consolidation area would necessarily occur in phases to accommodate the varying schedules of soil remediation and the demolition of structures in the former production area (as managed under Operable Unit 3). All production area facilities and above-grade utilities would be removed pursuant to the Operable Unit 3 Interim Remedial Action. Building slabs, foundations, underground tanks, underground facilities, contaminated perched water zones (see perched water extraction component description), and contaminated soil not meeting the capping WACs (within the footprint of the cap) or, as required by the consolidation area WACs, would be excavated. The excavated areas would be regraded and backfilled, as required, with imported clean fill material to create a suitable geologic base for the consolidation area. The consolidation area would be compacted and graded as necessary.

L.5.2.2 Material Placement

The consolidated material would consist of contaminated soil (untreated or treated) and/or cement stabilized soil blocks. The following sections describe the placement of each type of material.

Soil Placement

Contaminated soil would be delivered to the consolidation area in 40-ton roll-off containers and dumped in a stockpile near the active consolidation area construction site. Soil stockpiles would be wetted and/or covered to minimize fugitive dust emissions. Periodic monitoring, including sampling

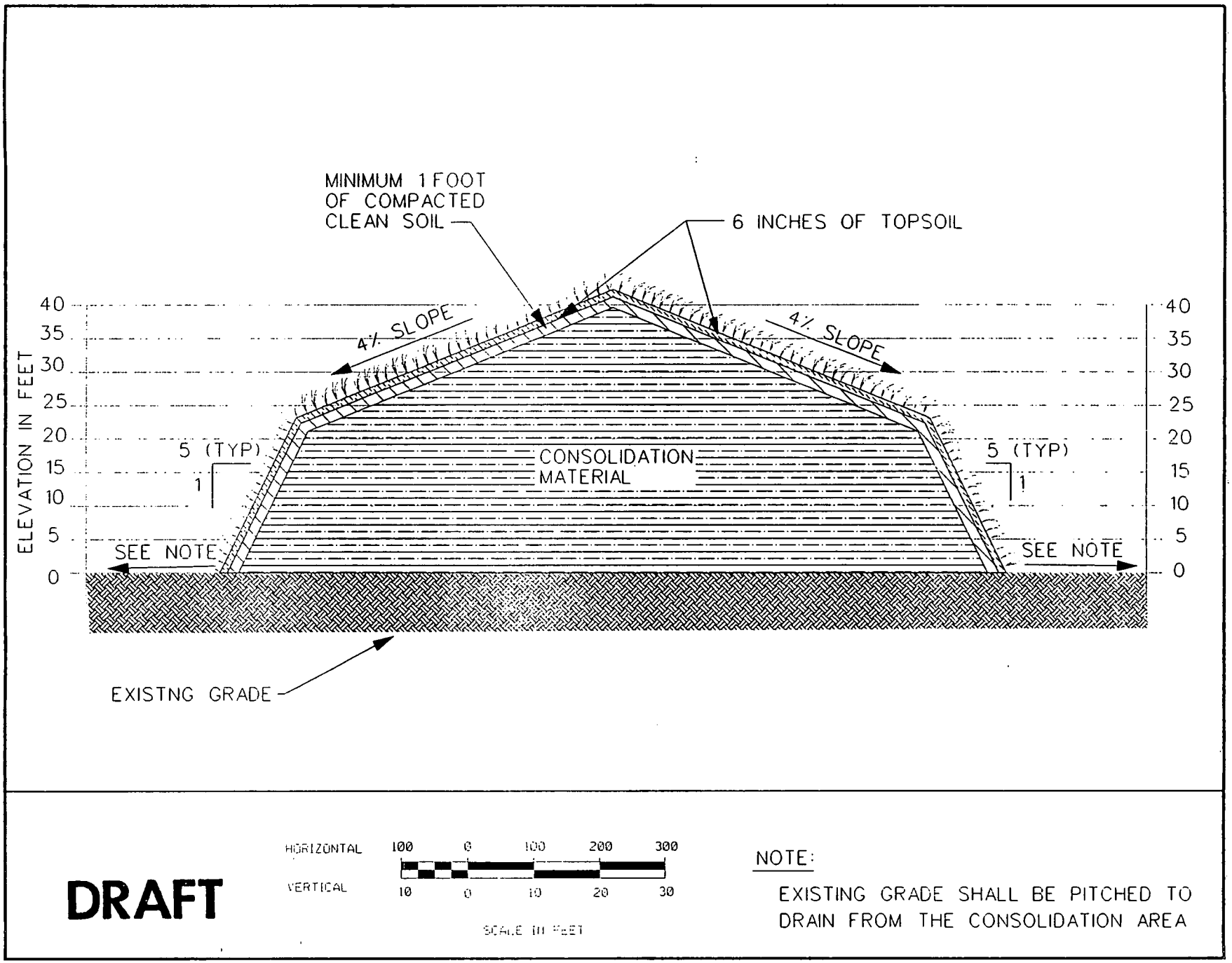

FIGURE L.5-1. CROSS SECTION OF CONSOLIDATION AREA WITH EARTHEN COVER

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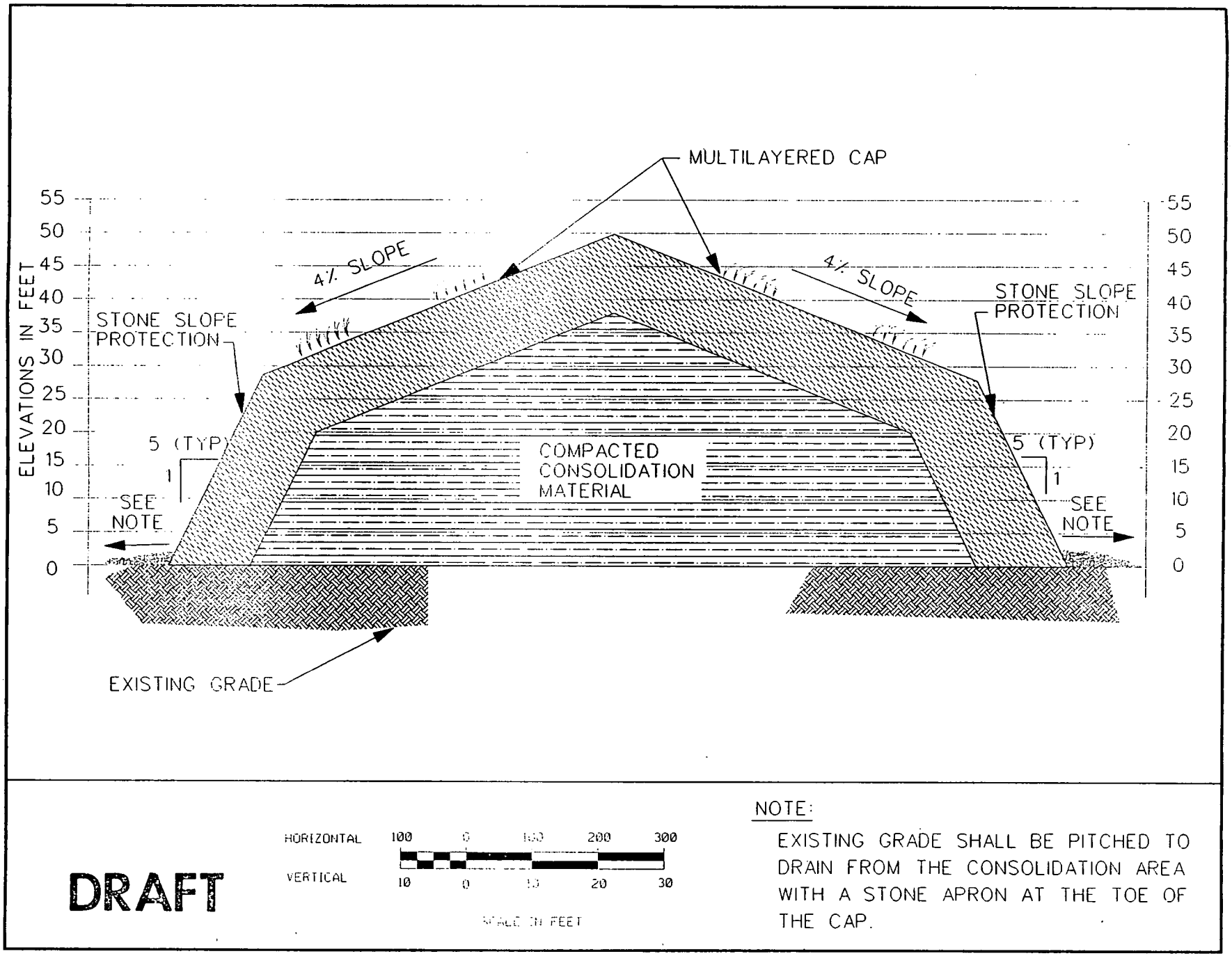

FIGURE L.5-2. CROSS SECTION OF CONSOLIDATION AREA WITH MULTI-LAYERED CAP

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and analysis of airborne particulates, would be conducted to ensure the effectiveness of dust suppression measures. Soil would be moved by front-end loaders or, if required, would be loaded into dump trucks and transferred to the consolidation area. Soil would be dumped, spread by bulldozer, and compacted in 8-inch lifts with a sheepsfoot roller. The consolidated material would be placed and graded to a 5:1 slope at the base and then sloped to a four-percent grade to the top of the mound. Following final grading, the consolidated material would be covered with an earthen cover or multilayer cap.

Stabilized Block Placement

Stabilized soil blocks would be delivered to the consolidation area on flatbed trucks. The blocks would be offloaded from the flatbeds and placed in the consolidation area by 7-ton capacity cranes. Stabilized blocks would be covered with compacted contaminated soil and graded as described above to allow placement of a multilayer cap.

L.5.2.3 Consolidation Area Cover

An earthen cover would be placed over consolidated contaminated soil meeting the WACs for an earthen cover. The stabilized blocks and contaminated soil whose contaminant concentrations exceed the WACs for the earthen cover would be covered with a multilayered cap. The following sections describe the design of each type of consolidation area cover.

Earthen Cover

The earthen cover consists of a minimum of 1 foot of compacted clean soil. Cover material would be placed in 8-inch lifts and compacted to achieve a 95 percent Standard Proctor. The compacted material would be covered with 6 inches of loosely compacted topsoil and revegetated for erosion control purposes.

Multilayer Cap

The conceptual design of the representative multilayer capping system selected to support the detailed analysis of remedial alternatives includes the following design considerations in addition to those mentioned earlier in this section:

- Attain regulatory and DOE order based design and performance based criteria including RCRA and State of Ohio hazardous waste landfill closure requirements, Uranium Mill Tailing Radiation Control Act requirements, and DOE 5820.2A criteria
- Be effective for up to 1000 years, to the extent practical and reasonably achievable, and in any case for at least 200 years (40 CFR 192.02)

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On the basis of these considerations, the cap configuration depicted in Figure L.5-2 was selected as the conceptual basis for the detailed analysis of alternatives. The cap configuration would be finalized during remedial design. The cap is based upon a composite design employing both natural materials, such as gravel and clay, and synthetic materials, such as polyethylene barriers. The capping system includes the following design components:

- A 6-inch-thick vegetative layer to reduce the potential for erosion
- A 3-foot-thick soil cover layer to accommodate moisture retention for maintaining the vegetative cover
- A 6-inch-thick gravel filter layer between a top and bottom layer of geotextile separator to protect the underlying biotic barrier from infiltration of fine grained silt and sand particles
- A 3-foot-thick biotic barrier consisting of cobbles to prevent animal and plant intrusion
- A 12-inch-thick sand drainage layer between a top and bottom layer of geotextile separator to drain off infiltrating water
- A double layer of textured high density polyethylene (HDPE) and a bentonite geocomposite layer to impede infiltration
- A 24-inch thick compacted clay soil layer, exhibiting a minimum 1 (x) 10^{-7} cm/year hydraulic conductivity, to impede infiltration and attenuate radon emissions
- Two 6-inch layers of compacted contouring fill surrounding a biaxial geogrid reinforcement material resting immediately above the contaminated soil and sediment to support the installation and contouring of cover materials.

L.5.3 STORM WATER CONTROL

Storm water contacting the consolidated material during construction would be collected and/or diverted to the existing SWRB for settling, and subsequently transferred to the AWWT facility for treatment before discharge to the Great Miami River.

Storm water run-on would be diverted around the consolidation area both during and after construction. During construction, adjacent areas would be graded to ensure positive surface water drainage away from the consolidation area. Silt fences would be used to control suspended solids present in storm water runoff from the construction site. The runoff would be allowed to sheet flow into the SWRB during remediation or would be directed by a probable maximum precipitation channel into Paddys Run after remediation. The channel would have a side slope of 4:1 with slope armor of 12 inches of riprap and 6 inches of bedding gravel.

L.5.4 COVER MATERIALS AND SUPPORT FACILITIES

Natural and synthetic capping materials, including the required clay, sand, and gravel, are envisioned to be imported from off-site sources. A temporary tension support facility would be assembled to provide a staging area for imported cover materials. Upon receipt, cover materials would be verified as meeting required specifications and placed into appropriate bins for ready access, as needed for construction activities. It is envisioned that a sufficient supply of capping materials would be on hand to facilitate construction of a cap of up to 150,000 square feet. Staging of these capping materials is required to provide flexibility for construction sequencing. During active cap construction, the staged capping materials would be transported from the storage facility to the actual capping site.

L.5.5 MAINTENANCE, MONITORING, AND INSTITUTIONAL REQUIREMENTS

The multilayer cap is intended to limit infiltration rates to levels that are protective of the Great Miami Aquifer. The consolidation area would require long-term maintenance and surveillance to ensure the continued performance of the system. Periodic maintenance, including inspection and groundskeeping of the vegetative cover, clearing of engineered surface water drainage ways, and inspection of the earthen cover or multilayered cap would be required. Inspections are assumed to be completed at the time of collection of groundwater monitoring samples. Maintenance, except as specifically required in response to inspection findings, is assumed to be conducted twice per year.

A long-term groundwater monitoring program would be implemented in support of any alternative using a consolidation area. A series of monitoring wells would be installed around the consolidation area boundary. The wells would be located in pairs, with one well installed in the glacial overburden and one well installed in the Great Miami Aquifer. For this study, it was assumed that one well pair would be placed every 150 linear feet around the boundary of the consolidation area. The actual number and locations of wells would be based on the final configuration of the consolidation area. A more detailed description of the groundwater monitoring network is provided in Section L.7.

The footprint of all consolidation areas would be fenced, delineated with permanent monuments, and maintained under the perpetual ownership of the federal government. Notations would be made in the property deed of the existence of the buried materials prohibiting intrusive activities into these areas. Through perpetual rights of ownership for the affected land parcels and continued surveillance and maintenance of the consolidation area, the potential for human intrusion to the buried contaminated soil and sediment, or for property development, would be minimized or completely eliminated.

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L.6.0 ON-PROPERTY DISPOSAL CELL

This component involves the construction of an on-property, above-grade disposal cell to provide permanent storage of contaminated materials including soil, sediment, gravel, and stabilized, dried remediation treatment sludges which meet the WACs established for the disposal cell. The major features of the disposal cell include a multilayered capping system coupled with a multilayered liner and leachate collection/detection system. Containment of contaminated materials in the cell would preclude the potential for direct contact, incidental ingestion/inhalation, or direct radiation exposure. It would reduce the migration of contaminants to air, surface water, and groundwater, achieving protectiveness for the Great Miami Aquifer.

The on-property disposal cell component is included as a support technology for the detailed analysis of alternatives under Land Use Objectives 2, 3, and 4. The rationale employed for siting the cell for this study was to select a location that took advantage of the existing site geology, topography, current land use, and anticipated remediation sequence. Thus, the northeast section of the site was selected as the proposed location for the disposal cell. Through fate and transport modeling, WACs have been developed for the materials that would be placed in the cell. The WACs are based on conservative fate and transport modeling assumptions, including the geologic conditions underneath the proposed disposal cell location, and are discussed in more detail in Section 4.0 and Appendix F.

Since the proposed disposal cell site contains some contaminated soil at primarily shallow depths, portions of this area would be excavated to remove contaminated soil. It is anticipated that this would occur in conjunction with the site preparation work associated with the construction of the disposal cell. Cut and fill operations are anticipated to establish the design grade for the cell's liner, depending on the design grade of the disposal cell's liner and the depth of excavation required to remove contaminated soil beneath the disposal cell's footprint. Fill areas would be constructed of clean, compacted soil to achieve the required design strength and permeability characteristics. The geologic conditions in the northeast section of the site appear to be suitable for the disposal cell location based upon the minimum 20-foot-thick gray clay layer observed during the Operable Unit 5 RI.

The liner of the cell would be designed employing conservative assumptions regarding the geochemical retardation and hydraulic properties of the existing, or subsequently backfilled, soil underlying the disposal system. For fate and transport modeling purposes, the upper brown clay layer of the overburden is also assumed to be absent. Geotechnical data would be collected during remedial design and evaluated to determine the applicability of additional engineering controls (e.g., in situ grouting) to augment the hydrogeology in the vicinity of the cell.

A geologic verification program is currently underway at the FEMP to collect supplemental data on the properties of the glacial till in the projected footprint of the disposal cell. These data will be used during remedial design to finalize the location, design configuration, and WACs of the disposal cell.

The actual size of the cell would be dependent on the volume of soil and other material requiring on-property disposal. The on-property disposal cell would require perpetual federal ownership, a groundwater monitoring system, an air monitoring system (during construction), radiation monitoring (during construction), restrictions within the property deed, permanent land markers, and a performance review of the continued protectiveness of the disposal cell at least once every five years.

L.6.1 DESIGN CONSIDERATIONS

The conceptual design of the representative disposal cell system selected to support the detailed analysis of alternatives includes the following design considerations:

- Attain regulatory and DOE order-based design and performance-based criteria including RCRA and State of Ohio hazardous waste landfill design requirements, Uranium Mill Tailing Radiation Control Act requirements, and DOE 5820.2A criteria
- Be effective for up to 1000 years, to the extent practical and reasonably achievable, and in any case, for at least 200 years (40 CFR 192.02)
- Minimize the rate of contaminant transport out of the disposal cell by minimizing the hydraulic transport of contaminants through the liner
- Accommodate disposal cell construction in modules to sequence construction activities with the soil remediation schedule and with the remediation activities of other operable units
- Minimize erosion of the cap and promote evapotranspiration through the use of a vegetative cover; provide erosion protection from cell runoff by constructing a stone apron along the toe of the cell and using a stone layer on the face of the berm
- Prevent erosion of the disposal cell berm through the use of a probable maximum precipitation channel constructed around the toe of the cell berm, as needed, to direct runon precipitation away
- Protect against animal and plant intrusion and minimize the potential for human intrusion though the use of stone barriers within the cell cap and on the face of the berm
- Minimize or completely attenuate the migration of radon from the contained radioactively contaminated materials
- Minimize the potential for settlement through compaction of the contaminated material in lifts and compaction of capping materials to the extent practical

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- Minimize the need for long-term surveillance and maintenance

- Provide for deed restrictions and monuments identifying the cell to further preclude the potential for human intrusion

- Minimize the potential for gas formation within the cell through segregation, to the extent practical, of the degradable organic material within excavated contaminated soil and the underlying soil column.

Additional considerations that are not specifically included in the representative disposal cell system selected to support the detailed analysis of alternatives, but could be incorporated into the future design include:

- Minimize the potential for a "bathtub effect" by incorporating a design such that the hydraulic conductivity of the liner is slightly greater than that of the cap

- Minimize diffusive contaminant transport by incorporating attenuating materials (e.g., zeolite, soil admixtures containing certain hydroxides of iron) into the composite liner design.

L.6.2 DISPOSAL CELL DESIGN

Upon consideration of the above, the disposal cell configuration depicted in Figure L.6-1 was selected as the conceptual basis for the detailed analysis of alternatives. The cell configuration would be finalized during remedial design. The components of the disposal cell design are described in the following sections.

L.6.2.1 Multilayer Cap

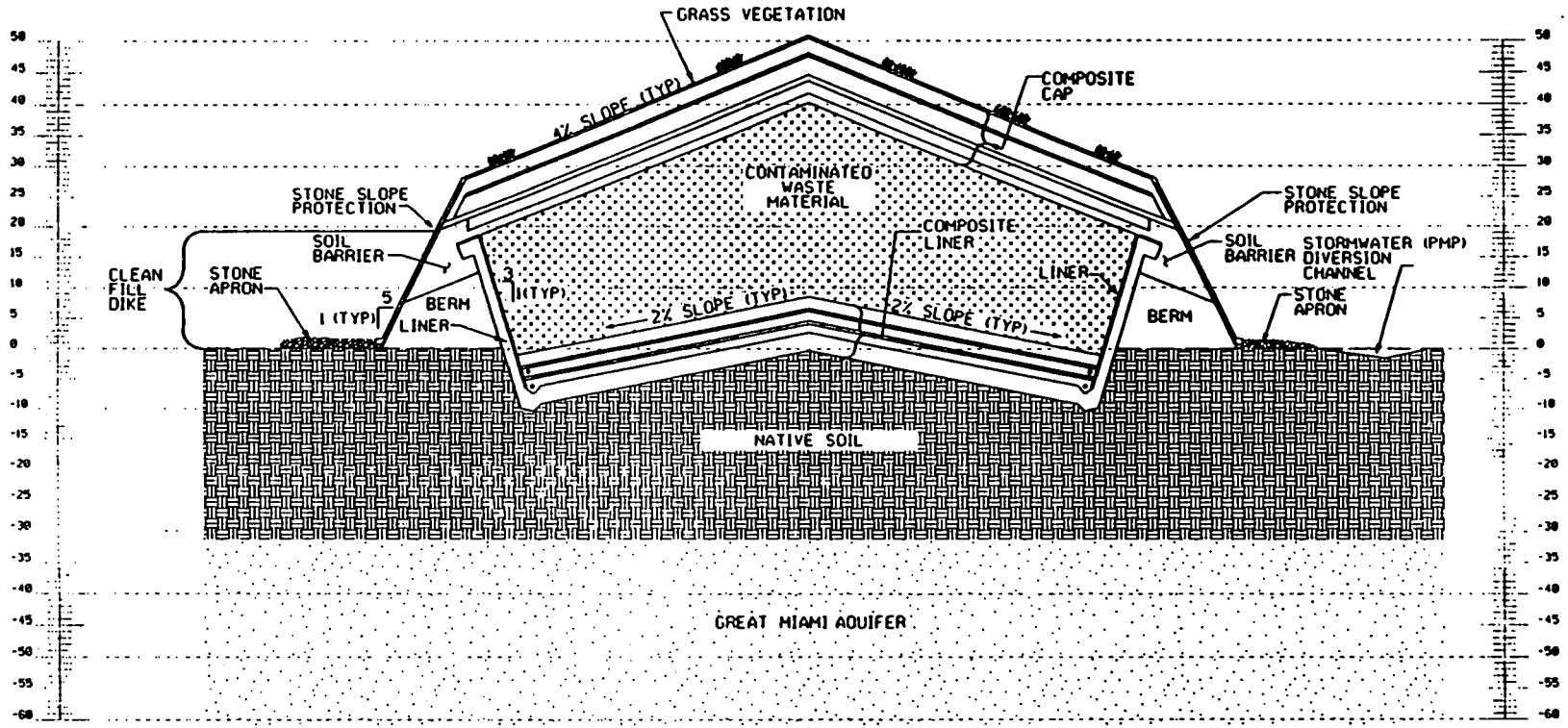
The details of the cap configuration are depicted in Figure L.6-2. The cap is based upon a composite design employing both natural materials, such as gravel and clay, and synthetic materials, such as polyethylene barriers. The cap would slope at about four percent from the crown out to clean fill dikes. The capping system includes the following design components:

- A 6-inch-thick vegetative layer to reduce the potential for erosion

- A 21-inch-thick soil cover layer to accommodate moisture retention for maintaining the vegetative cover

- A 6-inch-thick gravel filter layer between a top and bottom layer of geotextile separator to protect the underlying biotic barrier from infiltration of fine grained silt and sand particles

- A 3-foot-thick biotic barrier consisting of cobbles to prevent animal and plant intrusion



DRAFT

ABBREVIATIONS

PMP - PROBABLE MAXIMUM PRECIPITATION
TYP - TYPICAL

VERTICAL
10 0 10 20 30
SCALE IN FEET
HORIZONTAL
100 0 100 200 300
SCALE IN FEET

NOTES

1. GEOLOGY SHOWN FOR ILLUSTRATION PURPOSE ONLY.
2. DIMENSIONS ARE APPROXIMATE FOR A CELL CONTAINING 1 MILLION CUBIC YARDS OF WASTE MATERIAL.

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FIGURE L.6-1. CROSS SECTION OF DISPOSAL CELL

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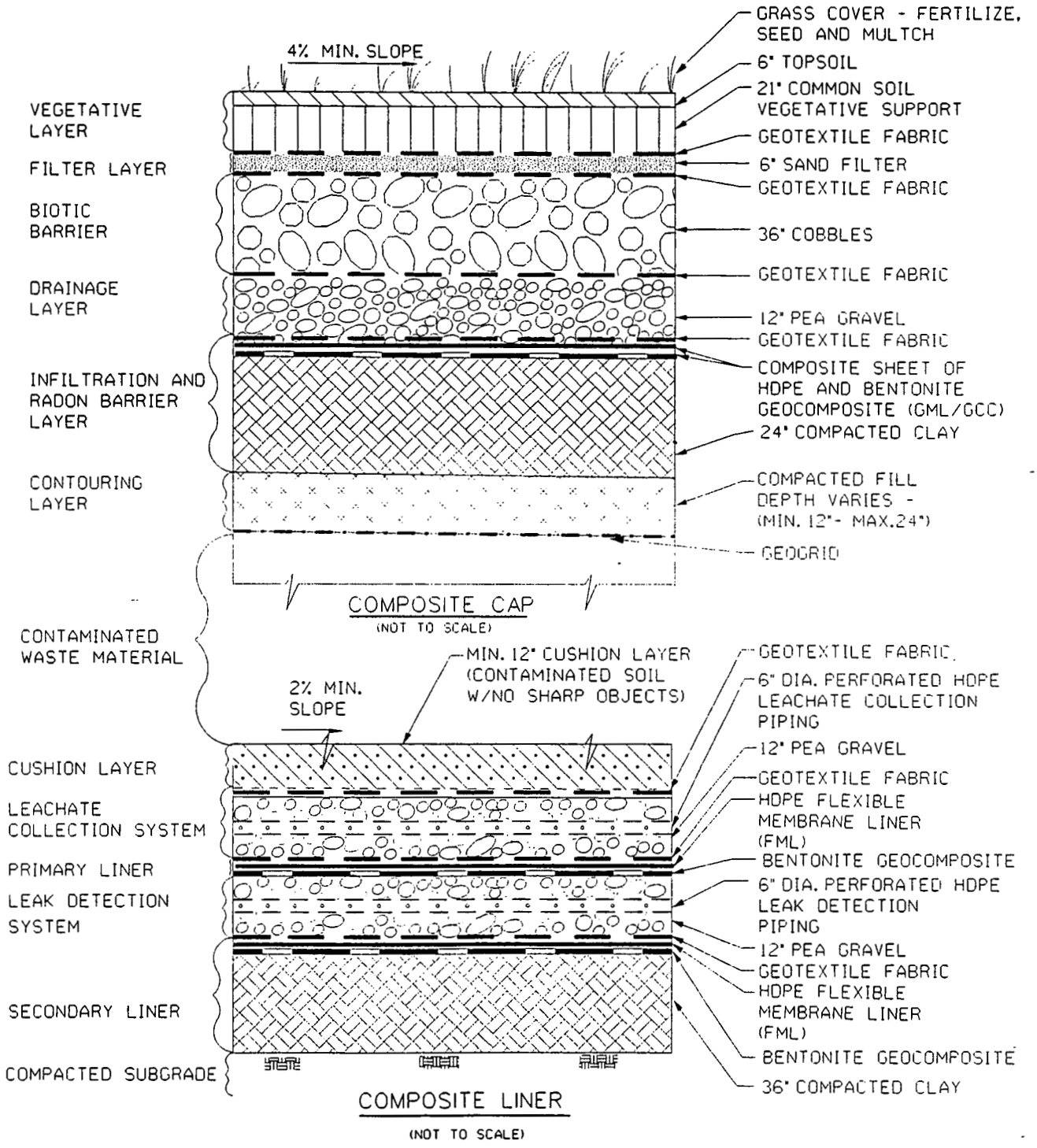

LEGEND:

- TOPSOIL
- VEGETATIVE SUPPORT
- CUSHION LAYER
- COMPACTED SUBGRADE
- GEOTEXTILE FABRIC
- GRASS COVER
- SAND
- COBBLES
- CONTOURING LAYER
- PEA GRAVEL
- COMPACTED CLAY
- HDPE FLEXIBLE MEMBRANE LINER (FML)
- BENTONITE GEOCOMPOSITE (GCC)

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FIGURE L6-2. DETAIL OF TYPICAL COMPOSITE CAP AND LINER

- A 12-inch-thick pea gravel drainage layer between a top and bottom layer of geotextile separator to drain off infiltrating water

- A composite layer consisting of textured HDPE over bentonite geocomposite layer to impede infiltration

- A 24-inch-thick compacted clay soil layer, exhibiting a maximum coefficient of permeability of 1 (x) 10^{-7} cm/sec to impede infiltration and attenuate radon emissions

- A varying thickness (12-inch to 24-inch, typical) layer of compacted contouring fill with a biaxial geogrid reinforcement material resting immediately above the contaminated material to support the installation and contouring of the cap layers.

L.6.2.2 Clean Fill Dikes

The clean fill dikes consist of the following design components:

- A core berm consisting of compacted soil material. This compacted material is covered with compacted clay. The berm would have interior slopes of 3:1 and exterior slopes of 5:1. The height of the clean fill dike from the existing grade to the edge of the disposal cell cover is dependent on the disposal cell size.

- A 12-inch-thick layer of 6-inch diameter stone on the exterior face for stabilizing and protecting the berm from erosion

- An apron of stone (10-foot-wide by 12-inch-thick, typical) along the toe to provide erosion protection from cell runoff.

L.6.2.3 Probable Maximum Precipitation Channel

The Probable Maximum Precipitation channel would be sized to protect the disposal cell from the probable maximum flood and would surround the uphill side of the cell. The channel would be offset from the clean fill dike at varying distances. The offset area between the cell and the channel would slope at 1 percent toward the channel. The channel would have a side slope of 4:1 with a channel invert sized depending on the disposal cell location's drainage basin (typically 10 to 20 feet). The side slope would be armored with 12 inches of riprap and 6 inches of bedding gravel.

L.6.2.4 Cell Liner

The details of the disposal cell liner configuration are depicted in Figure L.6-2. The liner would be constructed on a subgrade of clean compacted native soil and consists of the following design components:

- A protective layer (12-inch minimum, typical) consisting of a material such as soil or flyash to protect the liner when the waste is placed

- A geotextile fabric separator layer

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- An 12-inch-thick leachate collection system of pea gravel with 6-inch diameter perforated pipe to collect leachate and direct it to a collection point. Collected leachate would be piped to the AWWT. When the AWWT is removed from service, the drain piping at the cell would be plugged and removed from service.

- A geotextile fabric separator layer

- A primary geomembrane liner consisting of textured HDPE above and a geosynthetic clay liner below

- An 12-inch-thick leachate detection system of pea gravel and 6-inch diameter perforated pipe to collect leachate and direct it to a monitoring and collection point. When the AWWT is removed from service, the drain piping at the cell would be plugged and removed from service.

- A secondary geomembrane liner consisting of textured HDPE above and geosynthetic clay liner below

- A 36-inch-thick secondary liner of compacted native clay soil, enhanced by mixing with bentonite to ensure that permeability performance criteria are met.

The layering of the above-described liner is modified as it runs up the 3:1 interior slopes of the clean fill berms. The geosynthetic clay liners on the sloping clean fill berms are not used. Additionally a permeable geonet material is used to replace the pea gravel leachate collection and leachate detection layers. A geosynthetic rubsheet is used for the protective layer.

L.6.3 CELL CONSTRUCTION

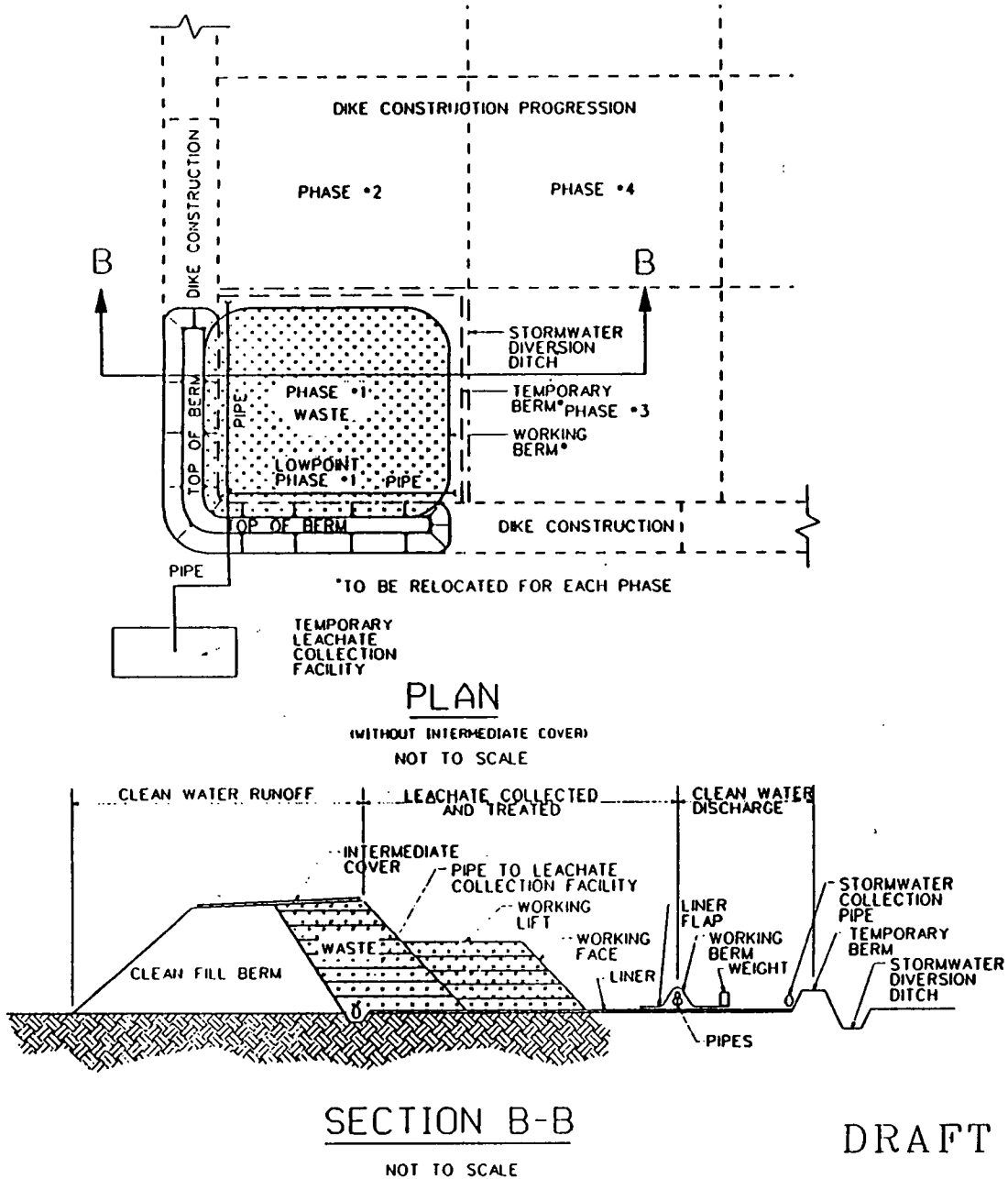
Before any waste placement, preparatory work is needed to establish the disposal cell's infrastructure and related support functions. The site should be cleared to a reasonable level (i.e. major vegetation removed, but not stripped to bare soil) to permit construction. Underground utilities, existing monitoring wells, and buildings need to be removed and depressions properly backfilled and compacted. Contaminated soil that underlies the cell would be excavated and the area deemed clean. Additionally, if required, any subsurface improvements, such as grouting or sand lens removal, would be performed. Due to the potential size of the disposal cell and the limited area for siting, underground utility removal and excavation would probably be conducted just in advance of the liner placement. Rough grading would be performed to establish the basal liner's drainage gradient. The high point of the storm water diversion ditches and the pitch of the ditches would be established. Clean topsoil excavated from these activities would be stockpiled for later use. Clean common soil would be used to construct the initial disposal cell's berms. Leachate collection ponds or sumps would be installed and pipeline routes laid to existing or new treatment facilities. For purpose of the study the leachate collection pipeline from the disposal cell is directed to the AWWT for treatment. Existing treatment facilities might need to be modified to handle additional volume and specific leachate constituents. Haul road routes, points of entry, wheel wash stations, and traffic patterns to

the disposal facility would be established. An initial disposal working cell would be sited and constructed.

Construction of the disposal cell would necessarily occur in phases to accommodate the varying schedules of soil remediation and the demolition of structures in the former production area (as managed under Operable Unit 3). The cell would be built and filled in subunits, or modules, with each module closed with an intermediate cover until completion of all planned modules. The final cap would then be constructed over the intermediate cover. Figure L.6-3 illustrates the concept of the progression of the disposal cell construction. Construction would start at one corner of the disposal cell footprint. A section of clean fill berm and disposal cell liner would be constructed first (illustrated as Phase 1). A temporary leachate collection system, storm water collection/diversion system, and working berm would be used to manage runoff water during construction. Control measures such as spraying with water or surfactants would also be employed to mitigate fugitive dust emissions during construction activities. Upon completion of the dike section, liner section, and leachate/storm water controls, waste material would be placed and compacted in lifts adjacent to the berm. The waste material would be placed in lifts to near the top of the clean fill berm and capped with an intermediate cover. The intermediate cover would most likely consist of a clay soil which also acts as the contour layer. A portion of this contour layer would be incorporated into the final disposal cell cap upon completion of the entire disposal cell. The working face and lift area would be limited to minimize the area exposed to weather during construction. During waste placement in Phase 1, construction of the next phases would progress as illustrated in Figure L.6-3.

It is feasible to prepare only one working cell in advance. Working cells would also be sized to handle one construction season's production (i.e. six months to one year). The weathering of basal and side liner materials (i.e., geomembranes degrade slowly in sunlight and clays desiccate when exposed) permits only a limited time for exposure to climatic elements. The initial lifts of waste next to the basal liner need to be select waste material, free of stones greater than 3 inches in size, rubble, and similar protruding objects. This layer should be placed 2 to 4 feet thick to prevent earthmoving equipment from puncturing the basal liner. Similarly, select waste material should be used next to the cover and the sidewall liner. Excavation and waste placement operations would incorporate this need for select material in their operations. Stockpiling of select waste material or reserving a waste borrow area would be necessary.

The size of individual modules would be planned based upon the remediation schedule, anticipating the amount of waste material to be disposed of over a given construction period. The modular concept allows for segregating the waste material within the disposal cell. Additional clean fill or residual waste soil could be used to construct berms upon the liner within the cell footprint to create subunit cells to facilitate waste management within the disposal cell. In a similar manner, the leachate collection and leak detection systems could be designed to collect leachate and monitor for leaks within individual subunits.



NOTES:

1. PLAN VIEW SHOWS THE FIRST WORK AREA. THE AREA EXPANDS AS ADDITIONAL WASTE IS PLACED.
2. THE WORKING LIFT AND FACE AREA IS LIMITED TO MINIMIZE AREA EXPOSED TO WEATHER.

FIGURE L.6-3 DISPOSAL CELL CONSTRUCTION PROGRESSION

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During cell construction, the area inclusive of the disposal cell and support facilities would be a controlled area. All vehicles exiting the controlled area must pass through a wheel washing/radiological screening station to minimize the spread of contamination to clean areas of the FEMP site.

L.6.4 WASTE PLACEMENT

Waste placement operations would be conducted concurrently with waste cell construction and cover installation. This is necessary to prevent basal liner materials, such as clays and geomembranes, from deteriorating before use. The active working face of the waste placement area would be kept relatively small over a short time, thus minimizing contaminated storm water runoff and exposure to wind erosion. The waste material placed in the disposal cell includes untreated contaminated soil, sediment and gravel.

Excavated contaminated soil and sediment would be transported to the disposal cell by roll-off container trucks. Temporary haul roads into the working cell area would need to be constructed and continuously modified as waste material placement expands in area and height. Construction of these temporary haul roads can be coordinated with the construction of adjacent future cell berms to minimize the earthmoving effort. The roll-off container trucks would dump the waste at the edge of the working cell. Earthmoving equipment, solely dedicated to waste placement operation within the cell, would spread and compact the waste in lifts. For example, a typical lift might be material spread 12 inches thick and compacted with a minimum of 4 equipment passes. Gravel would be placed in thin lifts in a manner that maximizes the ability to compact the material, and minimizes void space. Acceptable compaction and minimization of void space within the waste material are critical to minimize the potential for settlement of the final cap. A methods compaction specification for each type of the various major waste forms would be developed. Test pads of the various waste forms anticipated for placement would be constructed to determine the most suitable method and equipment for compaction.

Control measures such as water misting or surfactants would be used to mitigate dust releases during waste material placement. Periodic monitoring, including sampling and analysis of airborne particulates, would be conducted to ensure the effectiveness of dust control measures. To control contamination spread from wheel traffic, the earthmoving equipment placing the waste material within the cell would remain within the confines of the working cell, exiting only for maintenance. Roll-off container trucks delivering waste material to the disposal cell would have their wheels washed and radiologically screened for contamination before returning to the excavation site. A separate earthmoving crew would handle construction of berms, disposal cell basal liners, temporary haul roads and intermediate cover in clean work zones.

An interim outdoor waste stockpile area would be maintained adjacent to the working cell. The area would be large enough to accommodate several days to a week's capacity of excavation. The stockpile would be used during periods of inclement weather when waste material placement is not

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possible, and during periods of equipment downtime. The area also allows for some surge capacity, when excavation capacity exceeds placement capabilities. The stock pile area would be a lined pad with curbs and sump, or an extension of the working cell's basal liner. Provisions for covering the waste material in the stockpile with membranes or tarps and good positive drainage would be incorporated into the operating plan. Waste material from the stockpile would be placed into the working cell when weather conditions permit and during periods of slow excavation production.

L.6.5 MATERIALS AND SUPPORT FACILITIES

In addition to the outdoor contaminated waste material stockpile area and wheel washing/radiological screening station already mentioned, a staging area would be required for clean construction materials sufficiently sized to support the phased construction of the disposal cell. A covered facility for storage of the synthetic liner and cap materials would be needed to protect those materials sensitive to sunlight.

Construction materials would include bulk earthen materials (soil, sand, gravel, cobble, etc.,) for berm, cap, and liner, as well as synthetic materials (HDPE, geosynthetics, etc.) for cap, liner, and drainage systems. Additional materials would be needed to support storm water management (i.e., working berm, temporary piping, etc.), though much of this material would be reused as construction progresses.

L.6.6 MONITORING, MAINTENANCE, AND INSTITUTIONAL REQUIREMENTS

A long-term groundwater monitoring program would be implemented in support of any alternative using an on-property disposal cell upon final closure. A series of monitoring wells would be installed around the boundary of the cell. The wells would be located in pairs, with one well installed in the glacial overburden and one well installed in the Great Miami Aquifer. For this study, it was assumed that one well pair would be placed every 150 linear feet around the disposal cell boundary. The actual number and locations of wells would be based on the engineered and naturally occurring hydrogeologic characteristics of the final disposal cell location.

The on-property disposal cell would require long-term maintenance and surveillance to ensure the continued performance of the system. The access manholes for the leachate collection/detection system would be monitored to ascertain the system's performance and efficiency. Collected leachate would be removed by pipeline to the AWWT for treatment until the AWWT is removed from service. Periodic maintenance, including inspection and groundskeeping of the vegetative cover, clearing of engineered surface water drainage ways, and inspection of the cap and berm integrity would be required. Inspections are assumed to be completed at the time of collection of groundwater monitoring samples. Maintenance, except as specifically required in response to inspection findings, is assumed to be conducted twice per year.

Consistent with CERCLA and the terms of the Amended Consent Agreement, reviews would be conducted no less often than every five years after completion of remedial actions to assure that

human health and the environment are continuing to be protected at the site. These reviews would be performed by EPA, in consultation with OEPA. If, upon completion of such review, it is the judgment of the EPA that additional remedial actions or modifications to existing remedial systems are required, such actions would be implemented pursuant to the terms of the Amended Consent Agreement.

The footprint of the disposal cell area and any surrounding buffer areas would be fenced, delineated with permanent monuments, and maintained under the perpetual ownership of the federal government. Deed restrictions would be recorded to note the existence of the buried materials and to prohibit intrusive activities into these areas. Through perpetual rights of ownership for the affected land parcels and continued surveillance and maintenance of the disposal cell, the potential for human intrusion to the buried contaminated materials would be eliminated. The potential for development of the disposal area would be minimized or completely eliminated. Perpetual care of the disposal cell area would continue under the DOE or another federal agency, such as the U.S. Department of Interior.

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L.7.0 BACKFILL

This component involves the restoration of excavated areas by backfilling, regrading, and placing topsoil and a vegetative cover. In areas where the excavation activities impact the gray clay layer of the glacial overburden, the backfilled material would be augmented to ensure that the permeability of the backfill would be at least equivalent to that of the native material. For all alternatives, excavated areas would be backfilled with segregated clean soil and clean fill material borrowed from other areas on site or imported from off site. However, importation of backfill materials from off site sources would be minimized to the extent possible. Backfilling, regrading, and vegetation of excavated areas would enhance surface water drainage management, would provide an engineered base for the construction of other remedial action components (e.g., consolidation area), and would provide the topographic and aesthetic enhancements necessary for restricted and unrestricted land use.

The backfill component is included as a support technology for all remedial alternatives which contemplate soil excavation. The footprint of the backfilled area would be determined by that of the excavation area (see excavation component description, Section L.1.0). Backfilling of excavated areas would be minimized in that the majority of the site would be regraded to control water runoff. Deeper excavations, especially in the process area, would be backfilled to blend in with the new topography. Additional water collection ponds would not be created and the storm water management system would be designed to drain storm/surface water away from the FEMP site. Backfill materials would consist of both clean soil (less than PRLs) identified and segregated during excavation, and clean materials borrowed from other areas on site. All references to the use of clean borrow materials from on-site sources in this study imply that if sufficient quantity of material is not available on site, additional clean backfill materials will be imported from off-site sources. In those areas where excavated soil would include portions of the gray clay layer of the glacial overburden or in areas where the construction of former production area facilities previously breached the gray clay layer, backfill material would be augmented by adding bentonite to achieve a final permeability at least equivalent to that of the native material. Batch tests, using samples of both on-site borrowed soil and clean on-property segregated soil, would be conducted during remedial design to optimize the soil/bentonite mix.

L.7.1 DESIGN CONSIDERATIONS

The conceptual design of the representative backfill process selected to support the detailed analysis of alternatives includes the following design considerations:

- Minimize potential subsidence through compaction techniques
- Provide for soil augmentation with bentonite before backfilling in those areas where excavation of gray clay occurs or where previous activities breached the gray clay
- Minimize the need for borrow backfill materials from on site sources by efficiently using segregated, clean soil identified during excavation

- Minimize erosion and promote evapotranspiration through the use of grading and a vegetative cover.

L.7.2 BACKFILL DESIGN

Upon consideration of the above, the backfill configuration depicted in Figure L.7-1 was selected as the conceptual basis for the detailed analysis of alternatives. The figure depicts a cross section of a typical backfilled area finished with a layer of common fill, topsoil, and a vegetative cover.

L.7.3 BACKFILL OPERATIONS

Backfill operations would start once contamination surveys (as previously described in the excavation component) certify that excavated areas meet the established PRLs. Conventional earth-moving equipment such as bulldozers, wheel-tractor scrapers, soil compactors, and wheel loaders would be the primary pieces of equipment used for backfill operations. The type and size of equipment used would depend upon the shape and size of the area to be backfilled. Backfill operations would be conducted 8 hours per day, 5 days per week. Large, shallow excavations would be backfilled using bulldozers. Bulldozers are most versatile for backfilling operations and would be used to drag and spread materials for rough and finish grading. Soil compactors could be used to achieve a higher production rate, as they are equipped with front and rear rolling drums and can achieve compaction with fewer passes than a bulldozer.

Excavated areas would be backfilled first using available clean soil stockpiles before borrowing additional clean fill materials from on-site sources. Clean soil segregated during the excavation process would be moved from the segregation area to the backfill construction site. Soil stockpiles would be wetted and/or covered to minimize dust fugitive emissions. Periodic monitoring, including sampling and analysis of airborne particulates, would be conducted to ensure the effectiveness of dust suppression measures.

Backfill material would be placed in 8-inch lifts and compacted to achieve a 95 percent Standard Proctor. Deeper excavations would be backfilled and compacted using hydraulic hammer equipment. The hammer attachment would be mounted on a hydraulic excavator boom and powered by the excavator. Excavated areas would first be backfilled to a level that provides enough room to maneuver a soil compaction unit. At locations involving backfill in the gray clay, fill material would be blended with bentonite before emplacement and compaction. Bulldozers and soil compactors would then be deployed inside the excavation to continue grading operations. Areas backfilled with only clean, segregated soil from on property and/or clean borrowed soil from on-site sources would be brought to within 6 inches of the desired final grade. A 6-inch minimum layer of topsoil would then be placed as the final cover. All disturbed areas would be revegetated to control erosion.

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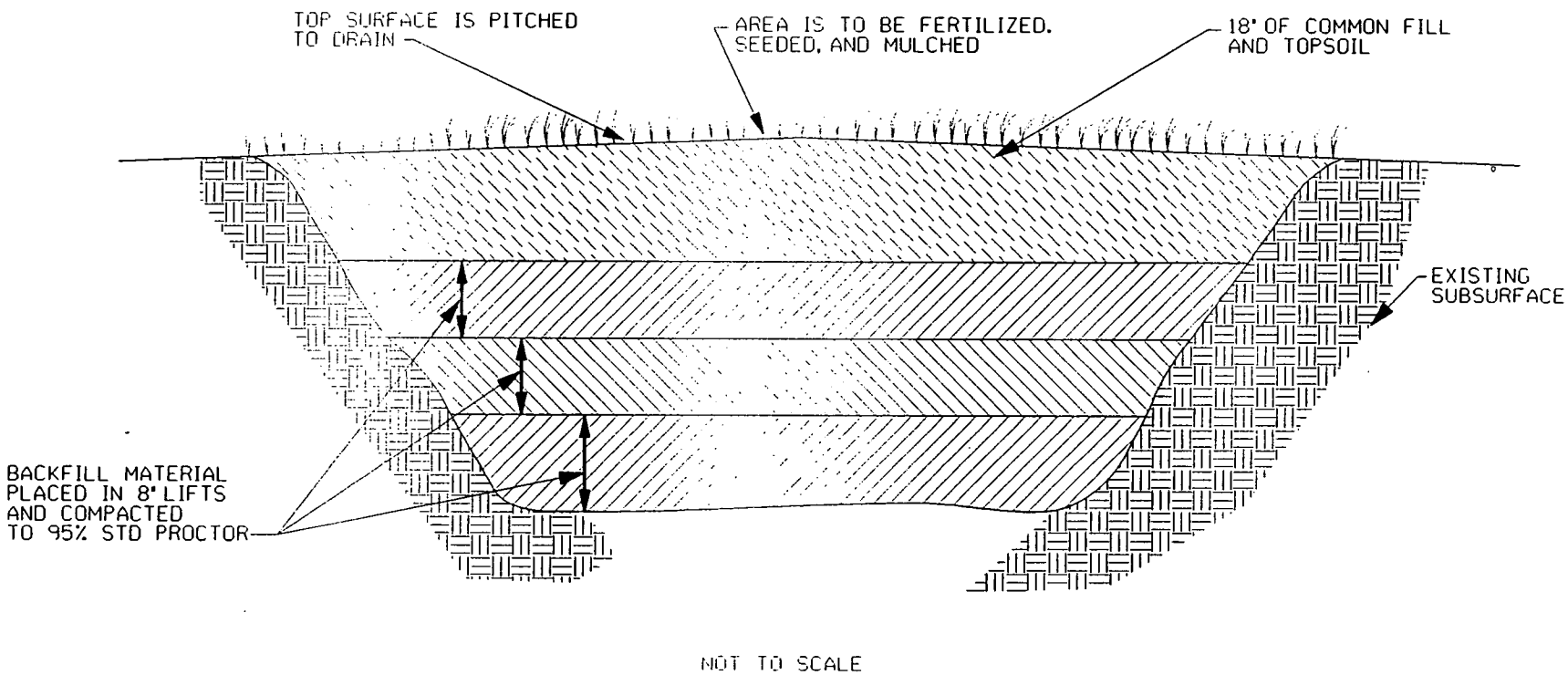

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FIGURE L.7-1. TYPICAL BACKFILL CROSS SECTION

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L.7.4 STORM WATER CONTROL

Storm water run-on would be diverted around active backfill areas. During construction, silt fences would be used to control suspended solids present in storm water runoff from the backfilling site. Regrading would be designed to integrate surface water runoff with the overall site surface water management system.

L.7.5 MATERIALS AND SUPPORT FACILITIES

Backfill materials would be excavated from on-property borrow areas and transported by dump trucks, as necessary. A staging area for clean construction materials would be required and would be integrated with the staging area for other components requiring clean fill.

L.7.6 MONITORING, MAINTENANCE, AND INSTITUTIONAL REQUIREMENTS

Areas backfilled only with clean, segregated soil and/or clean borrowed soil would not require long-term monitoring, nor would they be included in the scope of CERCLA five-year reviews. Consistent with the potential future land use configurations of the FEMP, some of these areas would be included in portions of the FEMP property to be made available for unrestricted, or partially restricted use.

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L.8.0 LONG-TERM ENVIRONMENTAL MONITORING

L.8.1. INTRODUCTION

This section discusses the general approach to long-term environmental monitoring at the FEMP during site cleanup and after final closure of on-site waste management facilities (e.g., disposal cell, consolidation areas). In general, environmental monitoring can be grouped into three broad categories: air pathway liquid pathway - effluent and surface water and liquid pathway - groundwater. A brief description of the current environmental monitoring program is provided in Section L.8.2. The current program provided the baseline that was used to estimate future environmental monitoring requirements and associated costs as cleanup and closure of on-site waste management facilities progresses. Section L.8.3 describes the anticipated changes in the environmental monitoring program during site remediation and post remediation. Section L.8.4 provides additional details regarding anticipated groundwater and air monitoring activities during site cleanup.

L.8.2. CURRENT FEMP ENVIRONMENTAL MONITORING PROGRAM

The FEMP currently implements an environmental monitoring program and conducts activities associated with three broad monitoring categories.

The air pathway monitoring includes the following activities:

- Air sampling for radioactive pollutants
- Soil sampling for uranium
- Grass sampling for uranium
- Produce sampling for uranium
- Milk sampling for radionuclides
- Monitoring for direct radiation
- Monitoring for nonradioactive pollutants
- Radon sampling.

The liquid pathway effluent and surface water monitoring includes the following activities:

- Effluent Sampling for Radionuclides
- Surface Water Sampling for Radionuclides
- Sediment Sampling for Radionuclides
- Fish Sampling for Uranium
- Sampling for Nonradioactive Pollutants

The liquid pathway groundwater monitoring includes the following activities:

- Private well sampling for uranium
- FEMP well network sampling for uranium
- FEMP well network sampling for other radionuclides

- Private well sampling for metals
- FEMP well network sampling for hazardous substances
- RCRA sampling

Table L.8-1 provides a summary of the current FEMP environmental monitoring program based on information presented in the 1993 site environment report. The table provides a baseline to evaluate anticipated changing environmental monitoring requirements as site cleanup is conducted.

The annual cost to implement the baseline environmental monitoring program described in Table L.8-1 is estimated to be approximately $2,000,000. This cost does not include the baseline groundwater monitoring program, which is estimated to cost an additional $4,000,000 annually.

L.8.3. PROJECTED ENVIRONMENTAL MONITORING PROGRAM

Based upon current remediation strategies, the cleanup for the overall FEMP site can be divided into three general time periods that would require varying degrees of environmental monitoring:

1) Construction monitoring period

2) Disposal facility postclosure and continued water treatment short-term monitoring period

3) Disposal facility post-closure long-term monitoring period.

The subsections below describe the general activities that will occur during each monitoring period and the environmental monitoring activities that will be required. Long-term monitoring will be used to validate modeling results.

L.8.3.1 Construction Monitoring Period

During the construction monitoring period, extensive construction activity is anticipated on the site property. Site buildings and the supporting infrastructure will be dismantled or demolished and disposed of. Shipments of wastes designated for off-site disposal will be transported off site. Excavation of contaminated soil and contaminated perched groundwater areas will be undertaken. Construction, filling with waste, and closure of on-site disposal facilities (e.g., disposal cell, consolidation areas) will be completed. Contaminated groundwater extracted from the Great Miami Aquifer by pumps, leachate from the disposal cell, contaminated storm water, and other cleanup-derived wastewaters would be treated at on-property treatment facilities. Effluent from the on-property treatment facilities would be discharged to the Great Miami River. The anticipated duration of this period is 22 years.

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TABLE L.8-1

SUMMARY OF CURRENT FEMP ENVIRONMENTAL MONITORING PROGRAM

Activity	Description	Sampling Locations
	Air Pathway	
Air sampling for radioactive pollutants	Monitoring of overall site emissions (fugitive and stack emissions) through the use of 20 air monitoring stations (AMS) which operate continuously	Six stations at site fence line; 3 stations on-site; 5 stations at schools and industries near the site; 2 stations for additional background data (Cincinnati and Miamitown, Ohio); 4 stations in waste pit area
Soil sampling for uranium	Site technicians collect annual soil samples at the AMSs and off-site locations to evaluate changes in uranium concentrations that might occur through deposition, soil resuspension, and other mechanisms	Nine on-site locations; 22 off-site locations
Grass sampling for uranium	Site technicians collect annual samples of grass at the same locations of the annual uranium soil samples. Uranium contamination in vegetation may result from the transfer of uranium from the soil through absorption by the plant, deposition of eroded soil, or from uranium deposited on the surface of the plant from the air	Nine on-site locations; 22 off-site locations
Produce sampling for uranium	Technicians sample produce each year to determine if uranium concentrations near the site (0-3 miles) are higher than concentrations in produce grown at distant locations (7-26 miles)	22 off-site locations
Milk sampling for radionuclides	Technicians collect monthly samples of milk from the dairy located adjacent to the FEMP and from a dairy in Indiana. Samples of milk are analyzed for radionuclides, including uranium, thorium, technetium, radium, strontium, cesium, and lead.	Dairy located adjacent to the FEMP; dairy located about 23 miles west of the FEMP

TABLE L.8-1
(Continued)

Activity	Description	Sampling Locations
	Air Pathway	
Monitoring for direct radiation	Direct radiation levels at and around the site are continuously measured with thermoluminescent dosimeters (TLDs)	29 on- and off-site locations
Monitoring for nonradioactive pollutants	The site estimates the amount of nonradioactive pollutants from its coal fired boilers including sulfur dioxide (SO_2), nitrogen oxide (NO_x), and carbon monoxide, using determined sulfur content of the coal and EPA-developed emission factors. Particulate emissions are estimated based on emission factors developed from stack testing conducted in 1988. Opacity of emissions is continuously monitored by instruments.	Two site coal-fired boilers
Radon sampling	The site uses two types of radon detectors to measure radon concentrations in the environment: alpha-track etch detectors and alpha-scintillation detectors	Alpha-track etch detectors: 20 locations at the site boundary, 3 area residences and four background locations Alpha-scintillation detectors: continuous monitoring at three fence line locations. Continuous monitoring at various locations on site including the perimeter of the silo berms and headspace of the silos (monitoring of the silos uses 24 detectors)

TABLE L.8-1
(Continued)

Activity	Description	Sampling Locations
	Liquid Pathway	
Effluent sampling for radionuclides	Currently the site's liquid effluent is categorized into 11 general sources (see Figure 1): 1) Waste pit perimeter storm water runoff 2) Waste pit area storm water 3) Perched groundwater (from areas within former production area, volatile organic compounds) 4) Plant effluent and pad storm water 5) Boiler plant blowdown and coal pile runoff 6) Water plant effluent 7) Lime sludge ponds decants 8) Laundry and sanitary sewage effluent 9) Production area storm sewers 10) Parking lot runoff 11) South Plume groundwater The site controls site-generated liquids, monitors and treats them as necessary before they all eventually enter Manhole 176B. There the effluents combine to form a single liquid effluent to the Great Miami River.	The mixed effluent is sampled at Manhole 175 and SP3 by automatic flow-proportional samplers to provide a daily flow-weighted sample of the effluent. A portion of each daily sample of effluent flowing through Manhole 175 and SP3 is analyzed for total uranium to determine the amount discharged to the Great Miami River. In addition, monthly composites are formed for Manhole 175 and SP3 by combining the month's daily samples at each location. The monthly composites are analyzed for four uranium isotopes and nine other radionuclides (trace radionuclides) The site also monitors any discharges that occur from the overflow of the storm water retention basin (SWRB).

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TABLE L.8-1
(Continued)

Activity	Description	Sampling Locations
	Liquid Pathway	
Surface water sampling for radionuclides	The site's surface water sampling program measures the effects of two potential sources of contamination to local waterways: 1) The discharge of liquid effluents into the Great Miami River. 2) Uncontrolled storm water runoff into Paddys Run and overflow from the SWRB. Weekly, the FEMP lab analyzes one of the daily samples from each of the Great Miami River sampling locations for total uranium. Portions of the daily samples are combined to form weekly and monthly composites for each location which are analyzed for radium-226 and radium-228. Six-month composite samples, prepared from the individual monthly composites, are analyzed for cesium-137, strontium-90, and technetium-99. Weekly grab samples along Paddys Run and a drainage ditch are analyzed for total uranium; radium was tested for in monthly composites.	Three locations along the Great Miami River: one upstream of the site's effluent discharge, two downstream Five on-site locations along Paddys Run Three off-site locations along Paddys Run One location along the drainage ditch originating near the pilot plant

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TABLE L.8-1
(Continued)

Activity	Description	Sampling Locations
	Liquid Pathway	
Sediment sampling for radionuclides	Sampling and analysis of sediments provide a way to evaluate the possible cumulative effects of routine discharges of treated effluent into the Great Miami River and the effects of storm water runoff into Paddys Run.	Eight locations at 33-foot intervals along the storm sewer outfall ditch (SSOD)
	Once a year, technicians collect sediment samples only at those locations where sediment is most likely to accumulate. All samples are analyzed for total uranium. Samples taken from the SSOD, Paddys Run above the SSOD, and Paddys Run were also analyzed for radium-226 and isotopes of thorium.	Nine locations along the Great Miami River Twelve locations along Paddys Run north of the SSOD Twelve locations along Paddys Run south of the SSOD Four background locations along Paddys Run, north of the site
Fish sampling for uranium	Fernald site personnel, with the help of a research team from the University of Cincinnati, collect fish by electofishing. The fish are analyzed for uranium. Once a year the sampling team collects fish at three locations along the Great Miami River.	River mile (RM) 38 - below the Route 127 bridge, North of Hamilton, Ohio RM 24 - at the FEMP's effluent discharge point RM 19 - at the outfall point of Paddys Run
Sampling for nonradioactive pollutants	The National Pollutant Discharge Elimination System (NPDES) permitting process for the FEMP site is under the jurisdiction of the State of Ohio to control the discharge of nonradioactive pollutants to Ohio waters. The permit specifies sampling locations, sampling and reporting schedules, discharge limits and other restrictions on the site's effluents discharged to the Great Miami River. (A total of 4020 samples were collected in 1993 in support of the NPDES compliance monitoring. NPDES samples were not taken from Paddys Run in 1993 since the SWRB did not overflow).	Current NPDES monitoring locations include (see Figure 1): Discharge 001 - Manhole 175 to Great Miami River Discharge 002 - SWRB spillway to Paddys Run Discharge 601 - sewage treatment plant Discharge 602 - general sump Discharge 604 - lift station Discharge 605 - bioreactor Discharge 606 - retention basin or SWRB

TABLE L.8-1
(Continued)

Activity	Description	Sampling Locations
	Liquid Pathway Groundwater	
Private well sampling for uranium	At a property owners request, any drinking water well near the site will be sampled for uranium to gain additional information about local groundwater quality, and the one-time sample results are reported to the well owner. If one of these "special request" samples shows a questionable or significant total uranium concentration, or if the well is believed to be representative of an area based on its location, the property owner has the option to participate in the routine sampling program.	During 1993, 36 off-site wells belonging to individuals and industries in the vicinity of the site were sampled monthly or quarterly.
FEMP well network sampling for uranium	A Comprehensive Groundwater Monitoring Program encompasses all sampling of site-owned monitoring wells. Site groundwater monitoring personnel do not monitor all wells each quarter, nor do they monitor all wells for the same constituents.	In 1993, the Groundwater Monitoring Program received results from 2003 analyses for total uranium from samples at 454 on- and off-site locations.
FEMP well network sampling for other radionuclides	The Comprehensive Groundwater Monitoring Program also samples for radium-226, radium-228, strontium-90, technetium-99, and thorium-232. Gross alpha activity, gross beta activity, cesium, plutonium, ruthenium, and neptunium are also monitored as indicators of radionuclide contamination.	The data for the 1993 sampling was not available for publication in the 1993 Environmental Report. A description of the locations and number of samples analyzed was not available.
Private well sampling for metals	Samples from private wells are analyzed for 16 metals.	During 1993, 36 off-site wells belonging to individuals and industries in the vicinity of the site were sampled.
FEMP well network sampling for hazardous substances	Various groundwater sampling programs monitor for nonradioactive constituents in groundwater to identify areas that might have harmful chemical concentrations as a result of past and present site activities.	All site wells are sampled and analyzed for metals, volatile organic compounds (VOCs), and water quality indicators listed in the National Primary and Secondary Drinking Water Standards.

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TABLE L.8-1
(Continued)

Activity	Description	Sampling Locations
	Groundwater	
RCRA sampling	In an effort to integrate CERCLA and RCRA monitoring activities under a single program, DOE proposed an Alternate Monitoring Program. The program comprised: 1) Groundwater characterization activities under CERCLA 2) Quarterly monitoring of the downgradient property boundary under the Routine Monitoring Program. A Revised Project-Specific Plan was submitted to OEPA in October of 1993 and defined the objectives of the Routine Monitoring Program. This program comprised 33 monitoring wells at the property boundary, including the monitoring wells installed for the downgradient monitoring network defined in the RCRA Groundwater Monitoring Plan.	RCRA groundwater monitoring activities will be incorporated into the Routine Monitoring Program comprised of approximately 33 monitoring wells at the property boundary.

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Table L.8-2 summarizes the environmental monitoring program elements that would be required during this period and comments regarding changes in the program with respect to the baseline environmental monitoring program.

L.8.3.2 Disposal Facility Postclosure and Continued Waste Water Treatment Short-Term Monitoring Perio

The disposal facility postclosure and continued water treatment monitoring period follows the construction monitoring period. During this period, the on-property treatment facilities continue to operate in support of the treatment of extracted groundwater and leachate from the on-property waste disposal facility. The anticipated duration of this monitoring period is approximately 8 or 53 years following final closure of the last on-property waste disposal facility, depending upon the groundwater cleanup goals (described in Section L.9.0).

Table L.8-3 summarizes the environmental monitoring program activities that would be required during this period and comments regarding changes in the program with respect to the construction environmental monitoring program.

L.8.3.3 Disposal Facility Postclosure Long-Term Monitoring Period

The disposal facility post-closure long-term monitoring period begins when groundwater pumping is no longer required and the groundwater treatment facility is removed from service and dismantled. During this period, only the closed on-property waste disposal facilities will require monitoring. This long-term monitoring will consist of groundwater and direct radiation monitoring, (typically at fence line locations). The duration of this monitoring period has not been established.

Table L.8-4 summarizes the environmental monitoring program activities that would be required during this period and comments regarding changes in the program with respect to the previous short-term environmental monitoring program. Section L.8.4 provides additional details regarding the projected groundwater and air monitoring activities.

L.8.4. ADDITIONAL GROUNDWATER MONITORING DETAILS

As described in Section L.8.3, groundwater and air monitoring activities will continue during and after completion of remedial activities. Some details of these groundwater and air monitoring activities are described below.

L.8.4.1 Groundwater Monitoring

The primary purpose of groundwater monitoring is to evaluate the effectiveness of the various remedial action components through early detection of constituents of concern (COCs) that may be released into the groundwater. Additionally, the monitoring is used to assess the performance of the groundwater extraction system. To that end, groundwater monitoring wells would be installed and sampled over a specified time period to provide performance data for the remedial action components.

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TABLE L.8-2

SUMMARY OF ENVIRONMENTAL MONITORING PROGRAM DURING THE CONSTRUCTION MONITORING PERIOD

Activity	Monitoring Activity Required	Comments
		Air Pathway
Air sampling for radioactive pollutants	Yes	Increased air sampling primarily with portable air samplers in localized areas where construction activities will generate fugitive emissions. Air monitoring will be incorporated into any new remediation facility design, as required. Upon final closure of the on-site waste disposal facilities, permanent air monitoring stations (AMS) will be located principally in the vicinity of the waste disposal facility.
Soil sampling for uranium	Yes	Soil sampling will continue at the currently established AMS locations (see Table 1) and be discontinued upon final closure of all on-site waste disposal facilities.
Grass sampling for uranium	Yes	Grass sampling will continue at currently established AMS locations (see Table 1) and be discontinued upon final closure of all on-site waste disposal facilities.
Produce sampling for uranium	Yes	Produce sampling will continue at the current level of effort and be discontinued upon final closure of all on-site waste disposal facilities.
Milk sampling for radionuclides	Yes	Milk sampling will continue at the current level of effort and be discontinued upon final closure of all on-site waste disposal facilities or cessation of grazing on the FEMP site.
Monitoring for direct radiation	Yes	Direct radiation monitoring will continue at the current level of effort. Upon final closure of the on-site waste disposal facilities, direct radiation monitoring (TLDs) will be located principally in the vicinity (along the fence line) of the waste disposal facility.
Monitoring for nonradioactive pollutants	Yes	Air monitoring for nonradioactive pollutants will continue as long as the coal-fired boilers remain in service, then discontinued. Air monitoring will be incorporated into any new remediation facility design, as required.
Radon sampling	Yes	Increased radon sampling primarily with portable samplers in localized areas where construction activities will generate radon emissions. Radon monitoring will be incorporated into any new remediation facility design, as required.

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TABLE L.8-2
(Continued)

Activity	Monitoring Activity Required	Comments
		Liquid Pathway Effluent and Surface Water
Effluent sampling for radionuclides	Yes	Effluent monitoring will continue. The level of effort is expected to decline as existing facilities are removed from service and demolished. At the end of the construction monitoring period, only the effluent from the wastewater treatment plant will require monitoring.
Surface water sampling for radionuclides	Yes	Surface water monitoring will continue. The level of effort is expected to initially increase as excavation and disposal facility construction are undertaken, then decline as areas are clean-closed and on-site disposal facilities are final closed. Upon final closure of all on-site waste disposal facilities, surface water monitoring with the exception of the Great Miami River monitoring will be discontinued. Great Miami River monitoring will continue until cessation of the groundwater pump and treat activity.
Sediment sampling for radionuclides	Yes	Sediment sampling will continue. The level of effort is expected to initially increase as excavation and disposal facility construction are undertaken, then decline as areas are clean-closed and on-site disposal facilities are final closed. Upon final closure of all on-site waste disposal facilities, sediment monitoring will be discontinued.
Fish sampling for uranium	Yes	Fish sampling will continue at the current level of effort while effluent from the site is discharged to the Great Miami River. The need for this sampling will be assessed throughout remedial actions to ensure its continued usefulness.
Sampling for nonradioactive pollutants	Yes	National Pollutant Discharge Elimination System monitoring will continue in compliance with the permit in effect. The level of effort is expected to decline as existing facilities are removed from service and demolished. At the end of the construction monitoring period, only the effluent from the wastewater treatment plant will require monitoring.

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TABLE L.8-2
(Continued)

Activity	Monitoring Activity Required	Comments
		Liquid Pathway Groundwater
Private well sampling for uranium and metals	Yes	This activity will continue until the alternate drinking water supply has been provided. Surveillance activities will continue to ensure that there are no additional users of affected groundwater.
FEMP well network sampling for uranium, other radionuclides, and hazardous substances	Yes	This activity will continue with a reduced set of radionuclide and hazardous chemical indicator parameters. It is anticipated that the level of effort will decline as site hydrogeology and contaminant plumes are fully characterized, and extraction systems are installed and put into operation. At the end of the construction monitoring period it is anticipated that groundwater monitoring wells will be used only for 1) monitoring the status of aquifer cleanup in the vicinity of the extraction wellfields, 2) monitoring for leaks along groundwater extraction system pipelines and 3) groundwater monitoring in the vicinity of on-site waste disposal facilities
RCRA sampling	Yes	This sampling will continue in accordance with requirements in effect at the time. It is anticipated that the level of effort for this activity will be integrated into an overall groundwater monitoring program for the site.

TABLE L.8-3

SUMMARY OF ENVIRONMENTAL MONITORING PROGRAM DURING THE DISPOSAL FACILITY POST CLOSURE AND CONTINUED WASTE WATER TREATMENT SHORT-TERM MONITORING PERIOD

Activity	Monitoring Activity Required	Comments
		Air Pathway Monitoring
Air sampling for radioactive pollutants	Yes	Permanent air monitoring stations will be located principally in the vicinity of the waste disposal facilities. Air monitoring will be conducted at the waste water treatment plant as required.
Soil sampling for uranium	No	Soil sampling will be discontinued upon final closure of all on-site waste disposal facilities.
Grass sampling for uranium	No	Grass sampling will be discontinued upon final closure of all on-site waste disposal facilities.
Produce sampling for uranium	No	Produce sampling will be discontinued upon final closure of all on-site waste disposal facilities.
Milk sampling for radionuclides	No	Milk sampling will be discontinued upon final closure of all on-site waste disposal facilities.
Monitoring for direct radiation	Yes	Upon final closure of the on-site waste disposal facilities, direct radiation monitoring (TLDs) will be located principally in the vicinity (along the fence line) of the waste disposal facility.
Monitoring for nonradioactive pollutants	Yes	Air monitoring will be conducted at the waste water treatment plant as required.
Radon sampling	Yes	permanent radon monitoring equipment will be located principally in the local vicinity of the waste disposal facilities.
		Liquid Pathway Monitoring: Effluent and Surface Water
Effluent sampling for radionuclides	Yes	Only the effluent from the wastewater treatment plant will require monitoring. Monitoring will be discontinued once compliance with applicable or relevant and appropriate requirements has been demonstrated.
Surface water sampling for radionuclides	Yes	Sampling of surface water at the Great Miami River locations will continue as long as the wastewater treatment plant continues to discharge effluent.
Sediment sampling for radionuclides	No	Upon final closure of all on-site waste disposal facilities, sediment monitoring will be discontinued.

TABLE L.8-3
(Continued)

Activity	Monitoring Activity Required	Comments
Fish sampling for uranium	Yes	The need for this sampling will be assessed throughout remedial actions to ensure its continued usefulness.
Sampling for nonradioactive pollutants	Yes	National Pollutant Discharge Elimination System monitoring will continue in compliance with the permit in effect. Only the wastewater treatment plant effluent will require monitoring.
		Liquid Pathway Monitoring: Groundwater Water Monitoring
Private well sampling for uranium and metals	No	Alternate drinking water supply will have been provided; Great Miami Aquifer groundwater contamination will be contained and/or cleanup will be in progress.
FEMP well network sampling for uranium, other radionuclides and hazardous substances	Yes	This activity will continue for a reduced set of radionuclide and hazardous chemical indicator parameters. It is anticipated that groundwater monitoring wells will be used only for 1) monitoring the status of aquifer cleanup in the vicinity of the extraction wellfields installed in areas with groundwater radionuclide contamination, 2) monitoring for leaks along groundwater extraction system pipelines and 3) groundwater monitoring in the vicinity of on-site waste disposal facilities
RCRA sampling	Yes	This sampling will continue in accordance with requirements in effect at the time. It is anticipated that the level of effort for this activity will be integrated into an overall groundwater monitoring program for the site.

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TABLE L.8-4

SUMMARY OF ENVIRONMENTAL MONITORING PROGRAM DURING THE DISPOSAL FACILITY POST CLOSURE LONG-TERM MONITORING PERIOD

Activity	Monitoring Activity Required	Comments
		Air Pathway
Air sampling for radioactive pollutants	No	Air monitoring conducted at the waste water treatment plant will no longer be required.
Monitoring for direct radiation	Yes	Thermolumin dosimeters will be located principally in the vicinity (along the fence line) of the waste disposal facility.
Monitoring for nonradioactive pollutants	No	Air monitoring conducted at the Waste Water Treatment Plant will no longer be required.
Radon sampling	No	Tendency on previous data not expected to require continued radon monitoring at on-site waste facilities.
		Liquid Pathway Effluent and Surface Water
Effluent sampling for radionuclides	No	No Wastewater Treatment Plant effluent discharges.
Surface water sampling for radionuclides	No	No Wastewater Treatment Plant effluent discharges.
Fish sampling for uranium	No	No Wastewater Treatment Plant effluent discharges.
Sampling for nonradioactive pollutants	No	No Wastewater Treatment Plant effluent discharges.
		Liquid Pathway Groundwater
FEMP well network sampling for uranium, other radionuclides, and hazardous substances	Yes	This activity will continue with analysis for a reduced set of radionuclide and hazardous chemical indicator parameters. It is anticipated that groundwater monitoring wells will be used only for groundwater monitoring in the vicinity of on-site waste disposal facilities.
RCRA sampling	Yes	This sampling will continue in accordance with requirements in effect at the time. It is anticipated that the level of effort for this activity will be integrated into an overall groundwater monitoring program in the vicinity of those on-site waste disposal facilities containing RCRA wastes.

L.8.4.2 Groundwater Monitoring Design

General guidelines from the EPA groundwater technical guidance document (US EPA 1992) were used in evaluating site-specific monitoring needs regarding the placement and number of monitoring wells in the areas of remedial alternative components. The following subsections provide a description of the installation of monitoring wells, sampling and analysis, operations and maintenance, and well abandonment requirements for groundwater monitoring wells.

Monitoring Well Installation

Initially, a groundwater monitoring detection system would be installed in the area of the various remedial action components. Figure L.8-1 depicts a typical monitoring well. A sufficient number of monitoring wells would be installed both upgradient and downgradient of each disposal unit so that background water quality is established and early detection of contaminant releases is possible. One pair of monitoring wells would be installed at about 150-foot intervals around the perimeter of the consolidation areas or the disposal cell. One well would be screened in the perched groundwater within the glacial till and the other well would be screened in the upper sand and gravel of the Great Miami Aquifer. Because local groundwater flow direction and gradients may fluctuate due to seasonal variations or pumping of on-and off-property groundwater extraction systems, monitoring wells would be installed on all sides of the monitored unit so that certain wells are always downgradient for detection purposes. Because final location, size, and configuration of each component is not currently known, the exact number of monitoring wells required would be determined during remedial design of each component.

For groundwater extraction, groundwater monitoring wells would be installed in the vicinity of the contaminated groundwater plumes to monitor cleanup progress and provide a means for calibration of the groundwater model used to assess and tune the extraction system.

Groundwater Sampling and Analysis

The projected operating period for the initial groundwater monitoring program would be consistent with the maximum period for which groundwater extraction and treatment is projected to occur (described in Sections L.9.0 and L.10.0). For the purposes of cost estimating, each groundwater monitoring well is assumed to be sampled on an annual basis during the active extraction period. After this period, it is envisioned that only monitoring specific to on-site disposal units will be required. For the cost estimate, a period of 50 years was assumed.

Water levels would be measured during each sampling event. Routine and quality assurance/quality control (QA/QC) samples would be collected from each monitoring well during each sampling event and analyzed for uranium-238, technetium-99, neptunium-237, strontium-90, thorium-232, barium, cadmium, cyanide, thallium, arsenic, pH, specific conductance, dissolved oxygen, and temperature.

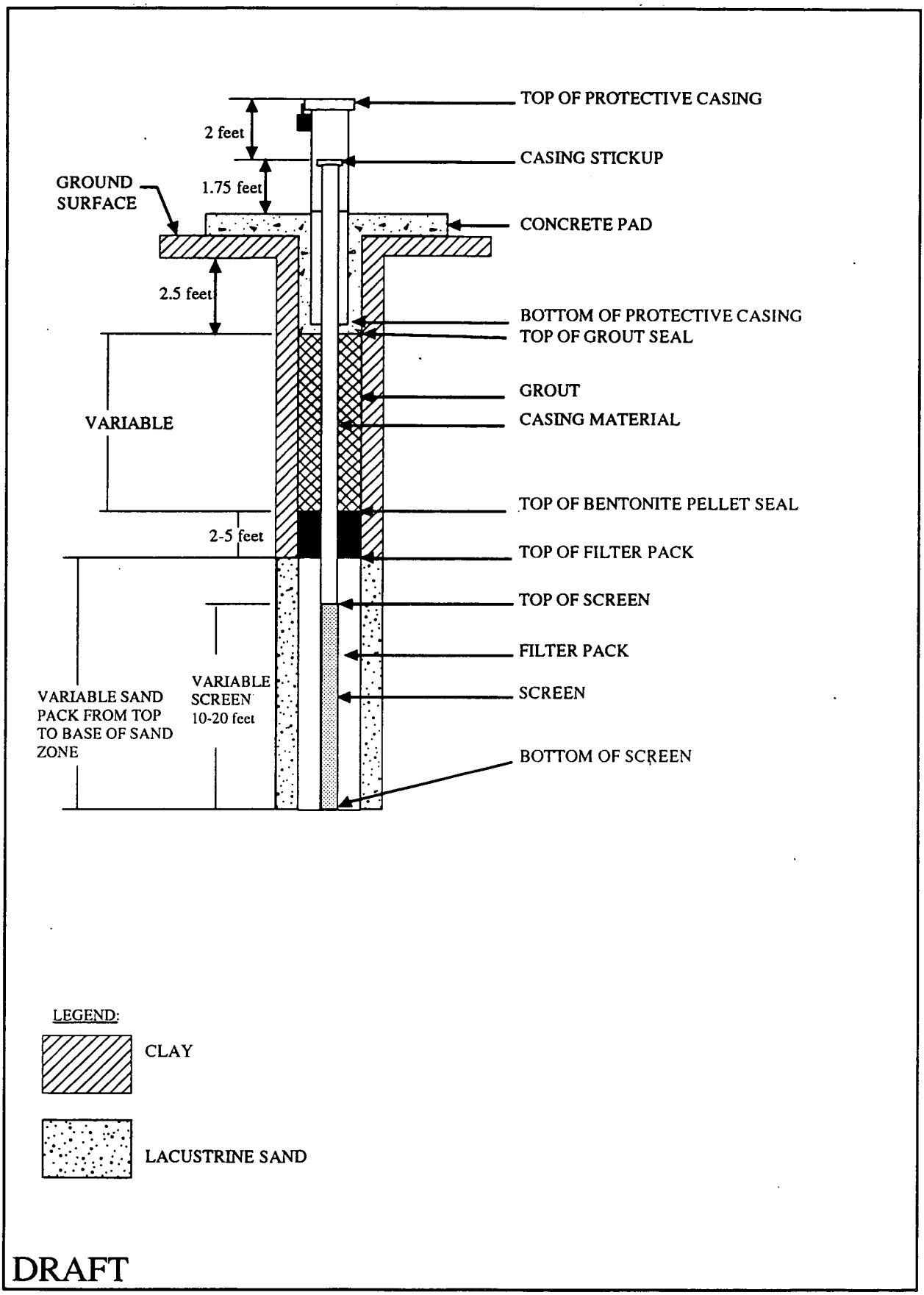

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FIGURE L.8-1. TYPICAL MONITORING WELL DESIGN

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Please note that these constituents represent a set of indicator parameters to be used for early detection of possible releases from remedial action components.

Maintenance

Periodic maintenance of groundwater monitoring wells and purge pumping equipment would be required to extend the life of the equipment and collect representative samples. Monitoring wells would be evaluated in regard to the wells performance and the condition and integrity of concrete pads, posts, locking caps, well caps, protective casings, etc.

Well Abandonment

After the completion of long-term monitoring activities, each monitoring well would be plugged and abandoned. Each monitoring well casing and screen would be removed by pulling and/or overdrilling, removing the annular space material, and filling the entire borehole with grout (i.e., Volclay) to within 30 inches of the surface, at which point a concrete plug would be poured to the surface. Removed materials would be drummed for proper off-site disposal as contaminated material.

L.8.5 ADDITIONAL AIR MONITORING DETAILS

The primary purpose of air monitoring is to provide detection of COCs released into the air during excavation and from on-site disposal units during their operational periods. Air monitoring at on-site disposal units will continue in the short term after closure until data trends show that air monitoring is no longer required.

L.8.5.1 Air Monitoring Design

Air monitoring stations will be strategically located on and around the perimeter of major excavation sites and on-site disposal units using site-specific meteorological information. Radon monitors will also be provided. In addition, monitoring devices will be located off site to provide background information.

L.8.5.2 Air Monitoring Station Sampling and Analysis

During contaminated soil excavation and operation of the disposal facilities, personnel will collect filters from each station for analysis at weekly intervals. The filters will be tested in a laboratory to determine the concentration of uranium. A portion of each sample solution is retained each week to prepare an annual composite, which is then analyzed for trace concentrations of other radionuclides such as radium, neptunium, plutonium, and thorium. The periodicity will be greater after closure of the disposal facilities, based on observed concentrations.

Radon monitoring will be accomplished using alpha-track etch or alpha-scintillation detectors. Alpha-track etch detectors are replaced every three months to provide long-term radon measurements, while alpha-scintillation detectors monitor continuously.

QA/QC samples will be taken periodically to verify results. Also, the FEMP laboratory participates in several QA programs conducted by independent organizations. Participation in these external programs provides unbiased evaluations of the on-site laboratory performance.

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L.9.0 GREAT MIAMI AQUIFER GROUNDWATER EXTRACTION

The purpose of the Great Miami Aquifer extraction component is to recover contaminated groundwater from the regional aquifer for subsequent treatment. The groundwater recovery is necessary to restore the contaminated portions of the aquifer to achieve PRLs. Active restoration would be accomplished using groundwater extraction designs comprised of up to four groundwater extraction well systems. Pumped groundwater, requiring treatment before discharge, would be sent to the groundwater treatment facility (GTF) while groundwater from systems meeting discharge requirements would be discharged directly without further treatment. Each system would be operated independently with discharge directed appropriately and withdrawn from service once remedial goals within an area are achieved.

Section 4.1 of the main text outlines the overall remedial strategy for the Great Miami Aquifer, including the basis for establishing the footprints of the geographic areas requiring remediation. From these footprints, SWIFT computer modeling simulations, using the previously constructed and calibrated FEMP flow and transport model, were conducted to identify the numbers, locations, and flow rates of extraction wells and to assess system performance and remediation times. These simulations included sensitivity runs designed to assess the effects of system variables on system performance and remediation time frames. From these simulations, two extraction system designs have been identified based on two groundwater remediation scenarios. One of these system designs, as appropriate, would be included as a component in each of the alternatives carried forward for detailed analysis in Section 5.0. The results of the modeling runs conducted for this analysis are presented in Appendix F, Fate and Transport Modeling.

As described in Appendix F, groundwater modeling was performed to evaluate the efficiency of various groundwater extraction system designs in reducing the maximum remaining uranium concentration in the Great Miami Aquifer to 20 ppb or 3 ppb (representing the MCL and 10^{-6} residual risk levels). All of the extraction system designs were modeled with unique well configurations and pumping rates to determine the time necessary to achieve the remediation objective. Each design was simulated with a baseline desorption K_d of 1.78 liter per kilogram (L/kg) based on FEMP Great Miami Aquifer data and the model calibration. Since slower desorption makes uranium extraction more difficult, a higher K_d of 12 L/kg was also simulated to determine a representative upper bound of cleanup time. Designs were evaluated based upon their simulated mass removal rate, system efficiency, the distribution of remaining uranium, and the average concentrations of contaminants in the extracted groundwater (treatment system influent). Depending upon the simulated K_d, cleanup times ranged from 30 to 55 years for the cleanup to 20 ppb, and from 70 to 105 years for the cleanup to 3 ppb. For the purposes of preparing a cost estimate, times of 30 and 75 years were assumed for cleanup to 20 ppb and 3 ppb, respectively.

The remainder of this section provides a description of the conceptual design of the Great Miami Aquifer groundwater extraction system component. This description provides the engineering basis for preparing the cost estimates for groundwater extraction as contained in Appendix K.

L.9.1 DESIGN CONSIDERATIONS

The conceptual design of the representative Great Miami Aquifer extraction systems selected to support the detailed analysis of alternatives includes the following design considerations:

- Provide for cleanup of the Great Miami Aquifer groundwater contamination plume to levels consistent with the PRLs in a reasonable amount of time at a reasonable extraction efficiency. These PRLs translate into aquifer restoration to uranium concentration levels of 20 ppb and 3 ppb.

- The representative extraction system designs were developed without regard to administrative barriers (e.g., operable unit and FEMP boundaries). For example, Wells 13, 14 and 15 (as shown on Figures L.9-1 and L.9-2) are located in the South Field which is proposed to be capped. In reality, some extraction well locations may change during remedial design.

- Extraction system enhancements (e.g., pulse pumping, reinjection, sparging) and design optimization (e.g., well locations, pumping rates, pumping sequences) were not considered during groundwater extraction modeling and development of the representative extraction system designs. However, refinement of the selected design and evaluation of extraction enhancement technologies will be considered and applied (with proper regulatory consent) during remedial design.

- As explained in Appendix F, groundwater modeling was performed primarily to simulate the extraction of uranium from the Great Miami Aquifer. The extraction of other contaminants, including neptunium-237, radium-226, technetium-99, antimony, arsenic, and manganese, was also simulated. MCLs for some other contaminants (e.g., radium, manganese, arsenic) are not expected to be attainable under either extraction scenario due to the low mobility of these contaminants.

L.9.2 EXTRACTION SYSTEM DESIGN

Based on the above considerations and the results of the SWIFT modeling, Great Miami Aquifer groundwater extraction systems were developed for two remediations scenarios. The first Scenario 1 provides for the reduction of groundwater contamination levels to MCL and proposed MCL concentrations (i.e., 20 ppb for uranium) within an estimated 30 years. Scenario 2 provides for the reduction of contamination levels to 10^{-6} groundwater PRLs (i.e., 3 ppb) within an estimated 70 years.

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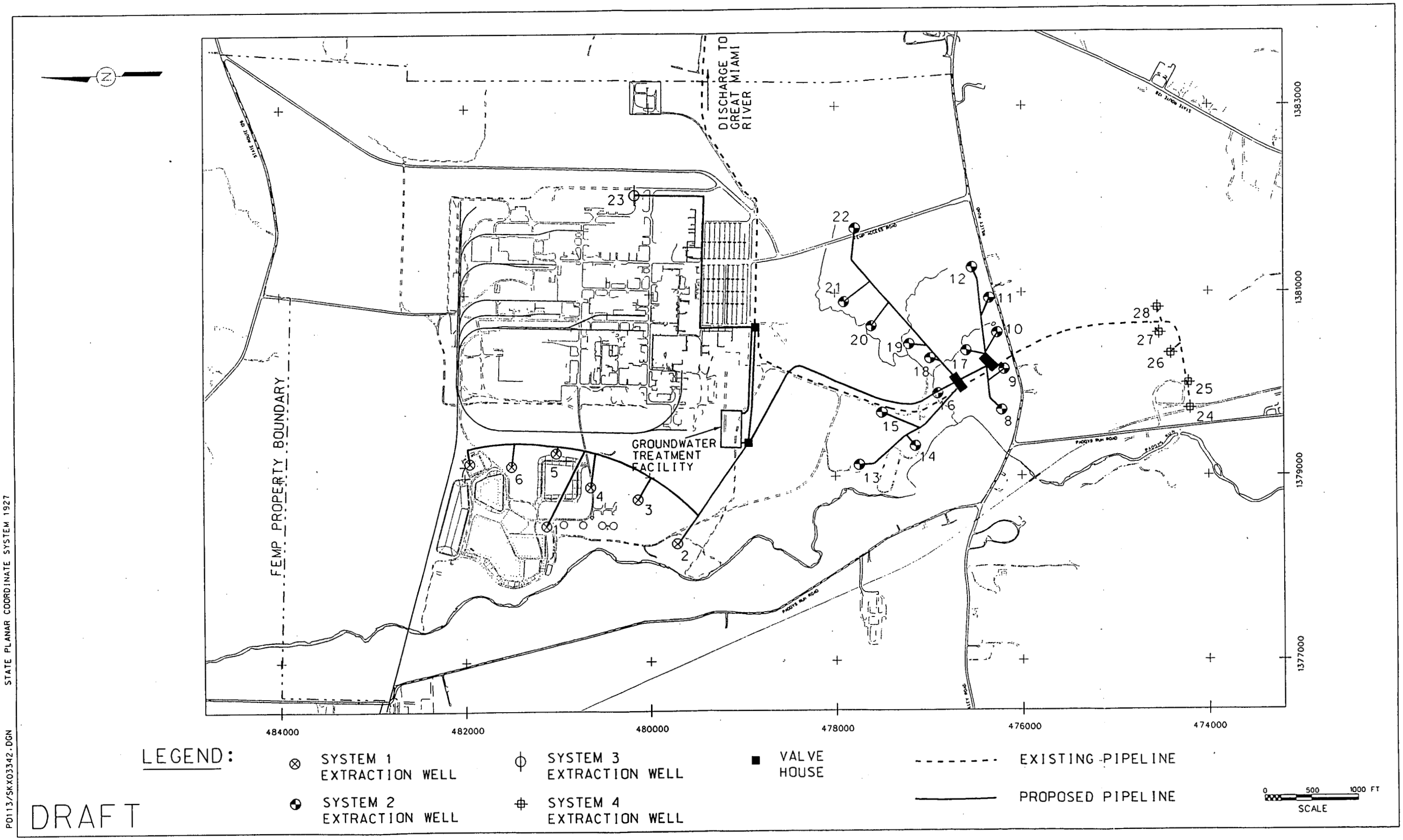
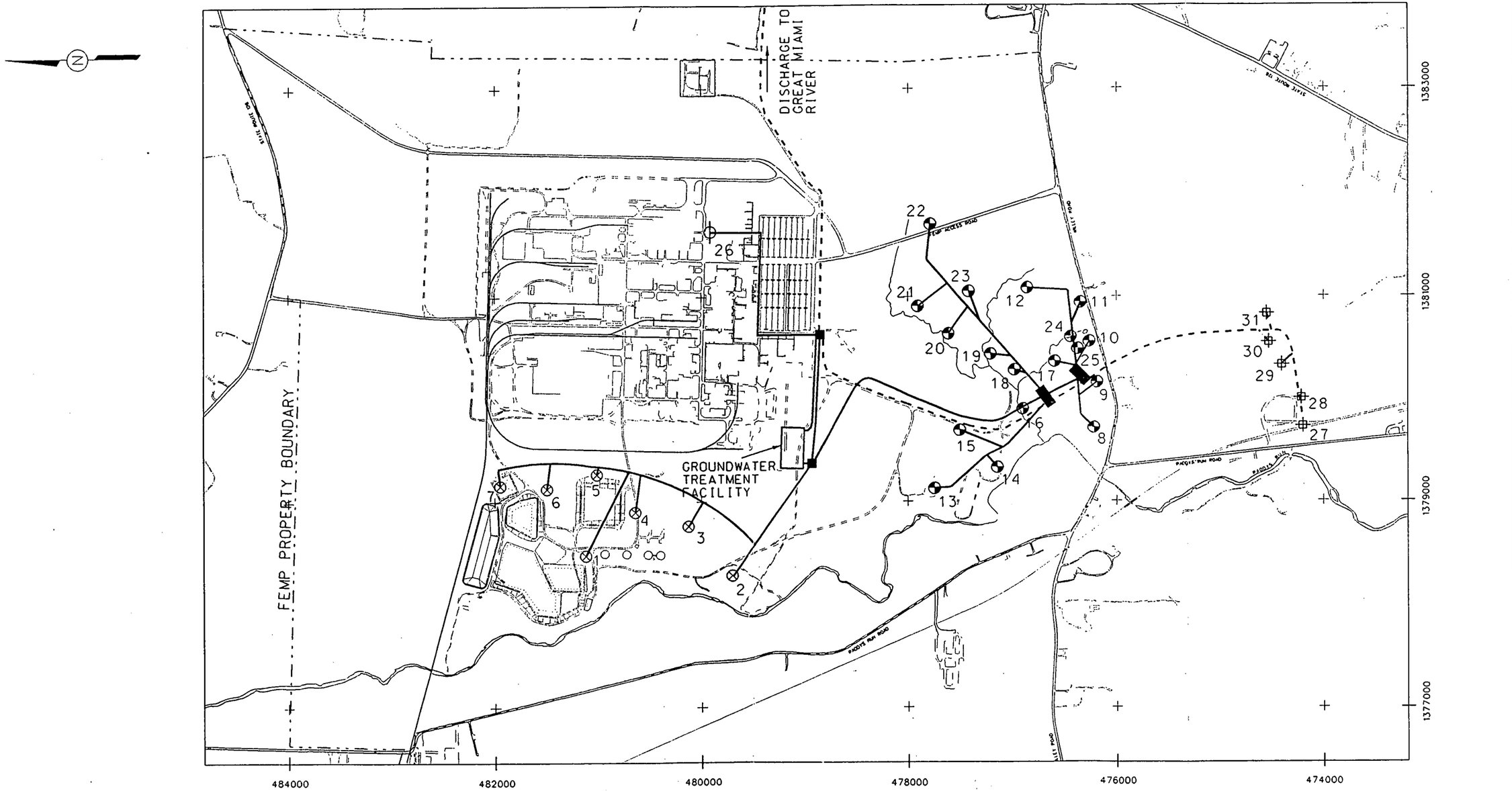


FIGURE L.9-1. RESTORATION TO 20 PPB
DESIGN - EXTRACTION SYSTEM COMPONENT LOCATIONS

FIGURE L.9-2. RESTORATION TO 3 PPB
DESIGN - EXTRACTION SYSTEM COMPONENT LOCATIONS



The Great Miami Aquifer groundwater extraction component is comprised of three new extraction systems in addition to the existing South Plume Recovery System. Each system is designed to recover a specific portion of the Great Miami Aquifer groundwater contamination plume. The four extraction systems for the two remediation scenarios are shown in Figures L.9-1 and L.9-2 and are described below. Where the scenarios require a different number of pumps or different pumping rates, the first number provided in the text is for the MCL/30-year scenario, while the number shown in parenthesis is for the 10^{-6}/70 year scenario.

- Extraction System 1: This system consists of seven extraction wells located along the down-gradient boundary of the uranium plume in the vicinity of the Operable Unit 1 waste pit area. Each extraction well is estimated to pump at a rate of 160-240 (200-300) gpm for a total system pumping rate of approximately 1300 (1600) gpm.

- Extraction System 2: This system consists of 15 (18) extraction wells located in the South Field area and along the southern FEMP property line. Each extraction well is estimated to pump at a rate of 160-400 (200-500) gpm for a total system pumping rate of approximately 3300 (5400) gpm.

- Extraction System 3: This system consists of a single extraction well located east of the production area. This extraction well is estimated to pump at a rate of 240 (300) gpm for a total system pumping rate of 240 (300) gpm.

- South Plume Recovery System: This existing system consists of five recovery wells located off-property to the south of the FEMP. This system became operational in 1993. Each recovery well is estimated to pump at a rate of 300 gpm for a total system pumping rate of 1500 gpm. Since this is an existing system, the cost of installing it is not included in the remedial alternative cost estimates.

A total of 23 (26) new extraction wells would be installed. The total number of wells in the extraction system would be 28 (31), including the 5 South Plume Recovery System Wells. The total extraction system pumping rate is estimated to be 6300 (7500) gpm. Tables L.9-1 and L.9-2 show the wells which would make up each system for both scenarios and their projected pumping rates.

Based on the computer modeling simulations, a 30 (70)-year extraction period has been adopted for use in the cost estimate. All new extraction wells would be installed the first five years of each extraction period. During remediation, the extraction systems would be operated in several different pumping configurations to maximize the efficiency of groundwater recovery over time as the area of contaminant concentration changes.

Each extraction system would be comprised of a number of extraction wells, pumps, and associated valves and pipelines. The following sections describe the design components of a typical extraction system.

TABLE L.9-1

GROUNDWATER RESTORATION TO MCL DESIGN, SCENARIO 1, PUMPING SCHEDULE

Extraction System	Well Number	Well Pumping Rate to 5 Years (gpm)	Well Pumping Rate 6 to 30 Years (gpm)
1	1	0	240
	2	0	160
	3	0	160
	4	0	160
	5	0	240
	6	0	160
	7	0	160
2	8	0	400
	9	0	320
	10	0	320
	11	0	320
	12	0	320
	13	0	160
	14	0	160
	15	0	160
	16	0	160
	17	0	160
	18	0	160
	19	0	160
	20	0	160
	21	0	160
	22	0	160
3	23	0	240
4	24	300	300
	25	300	300
	26	300	300
	27	300	300
	28	300	300
Systems total	28	1500	6300

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TABLE L.9-2

GROUNDWATER RESTORATION TO 10^{-6} DESIGN, SCENARIO 2, PUMPING SCHEDULE

Extraction System	Well Number	Well Pumping Rate to 5 Years (gpm)	Well Pumping Rate 6 to 25 Years (gpm)	Well Pumping Rate 26 to 70 Years (gpm)
1	1	0	300	0
	2	0	200	0
	3	0	200	0
	4	0	200	300
	5	0	300	300
	6	0	200	0
	7	0	200	0
2	8	0	500	500
	9	0	400	500
	10	0	400	500
	11	0	400	500
	12	0	400	500
	13	0	200	0
	14	0	200	0
	15	0	200	300
	16	0	200	300
	17	0	200	300
	18	0	200	300
	19	0	200	300
	20	0	200	0
	21	0	200	0
	22	0	200	400
	23	0	0	400
	24	0	0	300
	25	0	0	300
3	26	0	300	0
4	27	300	300	300
	28	300	300	300
	29	300	300	300
	30	300	300	300
	31	300	300	300
Systems total	31	1500	7500	7500

L.9.2.1 Extraction Wells

Figure L.9-3 depicts a typical Great Miami Aquifer extraction well design. Conditions may exist in the field which warrant variances from the typical well design. The major well components include:

- Wells would be constructed using a 60-to 120-foot length of 16-inch outer diameter (OD) 316 stainless steel casing, and 40 feet maximum of 16-inch OD stainless steel, wire-wrapped well screen.

- The top of the well screen would be set at the anticipated average water table elevation. The screen slot size would be estimated at 0.05-inches, but sieve analyses would be used to determine optimal screen and filter pack size.

- Filter pack material would be well-sorted quartz sand and would extend approximately 2 feet above the top of the screen.

- A 2-5 foot bentonite pellet seal would be placed above the sand pack.

- The remainder of the annular space would be filled with a bentonite-cement grout slurry to a depth of approximately 15 feet below ground surface where a pitless adaptor would be installed to connect to the discharge piping system.

L.9.2.2 Pumps

Each extraction well would require a 12-inch OD (maximum), submersible, multistage, turbine pump with up to a 400 (500) gpm pumping capacity at 130 feet total dynamic head and a 30 (40) horsepower, 480 volt, three-phase motor equipped with a flow shroud. A variable speed controller would be used to adjust pumping rate. These adjustments would be made and monitored remotely from the main control room in the centralized treatment facility.

L.9.2.3 Valves

A valve/meter pit associated with each extraction well would contain a remotely operated isolation valve and pressure and flow instruments. These instruments would also be monitored remotely from the centralized treatment facility. A control building would be provided at each recovery well for power distribution and control circuitry.

L.9.2.4 Pipelines

Each of the extraction subsystems would pump to a system header which would in turn discharge to either a treatment header or a discharge header. The treatment header would transport water from the systems whose concentration levels require treatment. This flow would be directed to the GTF for treatment before discharge. Systems whose effluent contaminant levels are low enough that treatment is not required would pump to the discharge header. The discharge header was previously installed in 1993 to support the South Plume Recovery System. The discharge header has a capacity of 7500 gpm and runs from the South Plume Recovery System north, through the South Field, and then northeasterly to a valve house located at the SWRB.

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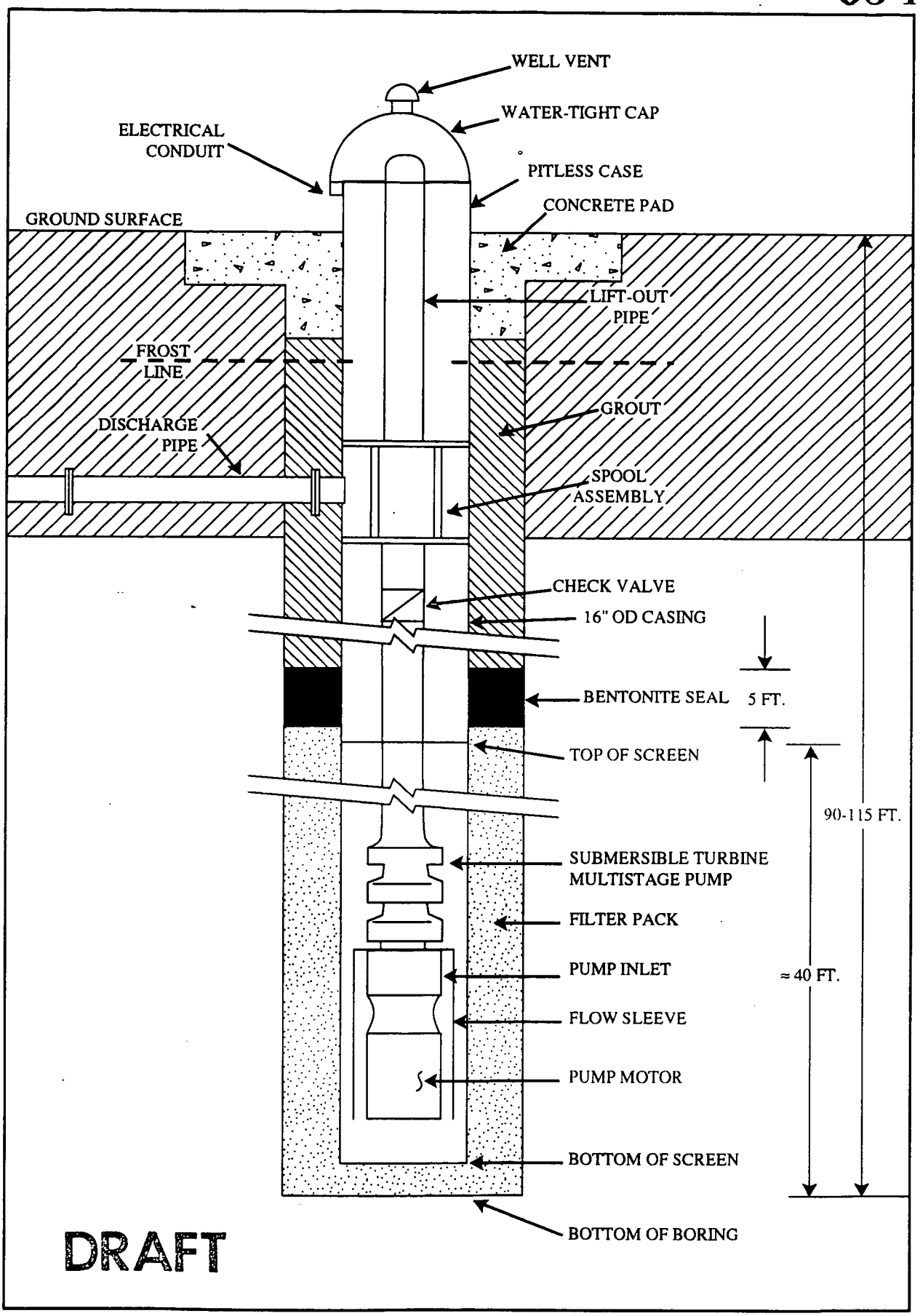

FIGURE L.9-3. TYPICAL RECOVERY WELL

The new extraction system headers and treatment header would be constructed of HDPE pipe. The pipelines would be buried below the frost line and placed over a gravel sump at the bottom of the pipe trench. Each header would be provided with vent and drain lines for system maintenance.

L.9.3 SYSTEM ABANDONMENT

After completion of remediation activities, each extraction well would be plugged and abandoned in accordance with Section J.4.3. of the SCQ. For the purpose of the estimate, each well pump, casing and screen would be removed by pulling and/or overdrilling, the annular space material removed, and the entire borehole would be filled with grout (i.e., Volclay) to within 30 inches of the surface at which point a concrete plug would be poured to the surface. Also, related discharge piping and electrical materials would be excavated. Removed materials would be drummed for off-site disposal as contaminated material.

L.9.4 MONITORING, MAINTENANCE, AND INSTITUTIONAL REQUIREMENTS

A series of groundwater monitoring wells would be or has been installed in the area of the four groundwater extraction systems for the purpose of evaluating the performance of the groundwater extraction design, delineating the capture zones; and anticipating the future contaminant concentrations. A number of monitoring well pairs would be installed upgradient and downgradient of each of the extraction systems. The actual number and design of the well pairs would be determined during remedial design, based on hydrogeological conditions encountered in the field. Figure L.9-4 depicts a typical monitoring well design. The major components of the monitoring wells include:

- Wells would be constructed using a 4-inch nominal OD 316 stainless steel casing and 4-inch OD stainless steel, wire wrapped well screen (40 feet maximum length).
- The screen would be set at the anticipated average water table elevation. The screen slot size would be approximately 0.05 inches as determined by sieve analysis.
- Filter pack material would be well-sorted quartz sand and would extend approximately 2 feet above the top of the screen. A 2-5 foot bentonite pellet seal would be placed above the sand pack.
- The remainder of the annular space would be filled with a bentonite-cement grout slurry to a depth of approximately 2.5 feet below ground surface and then finished with a concrete pad.

Extraction and monitoring wells, discharge piping, and electrical systems would be maintained over the 30 (70)-year period of operation. Periodic maintenance of groundwater extraction wells and related piping would be required to extend the life of the well and collect representative samples.

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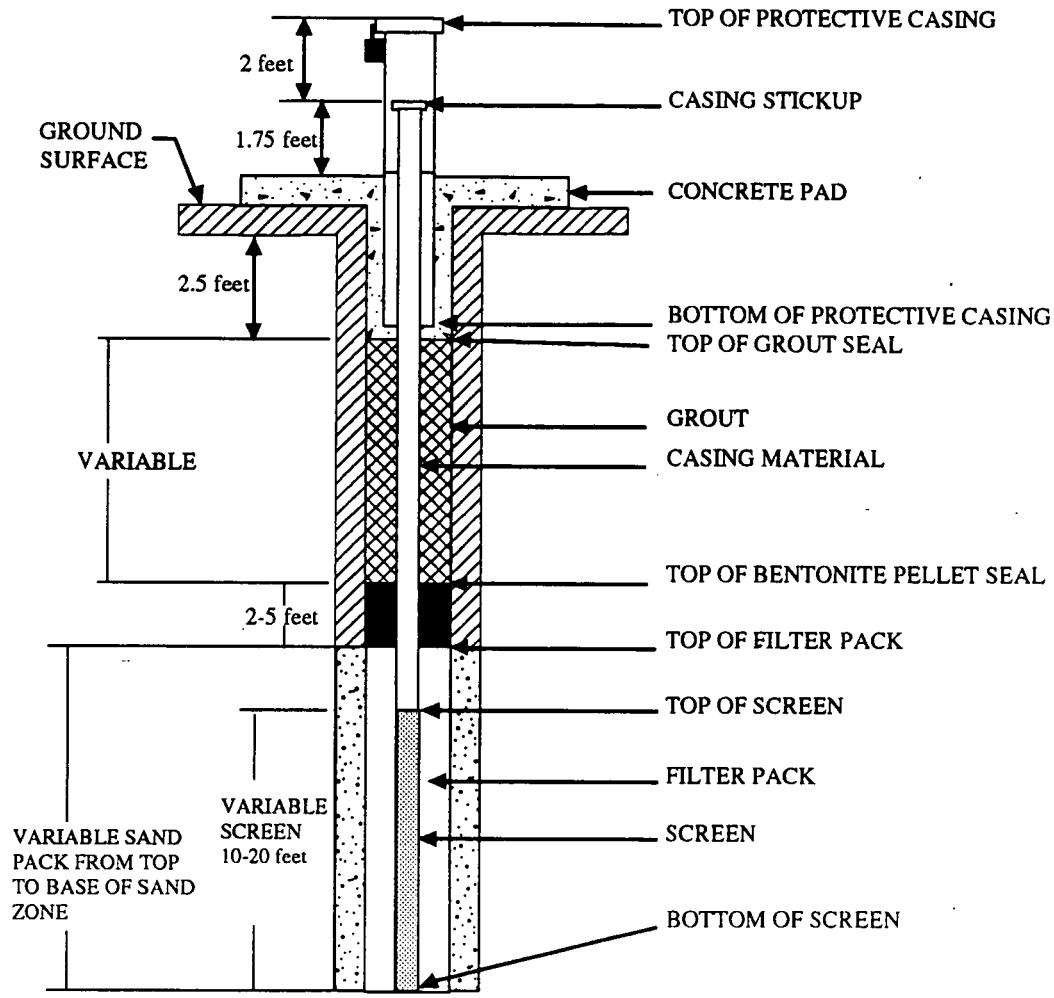

MONITORING WELL DIMENSIONS

DIMENSION	TYPE 1	TYPE 2	TYPE 3
SCREEN LENGTH (FT)	10	20	20
CASING LENGTH (FT)	15	50	90
MAXIMUM ANTICIPATED TOTAL DEPTH (FT)	25	70	110

LEGEND

Clay

Lacustrine Sand

DRAFT

ERAFS2\MACDATA\ILLUSDATA\OU-5\PO-113\PERCH WAT MONITOR WELL.EPS

FIGURE L.9-4. TYPICAL MONITORING WELL DESIGN

Wells would be periodically evaluated with respect to well performance and the integrity of pumps, concrete pads, posts, protective casings, well casings, etc. Wells and well equipment, including pumps and associated piping, would be replaced as required to maintain the extraction system performance over the 30 (70)-year operation period.

The Great Miami Aquifer groundwater extraction system, inclusive of wells, pumps, and pipelines, would remain under federal ownership during the period of operation. Underground pipelines would be marked by permanent monuments. Institutional controls would be maintained during the active restoration period to prevent access to contaminated groundwater.

L.10.0 GROUNDWATER AND WASTEWATER TREATMENT

L.10.1 INTRODUCTION

Groundwater Treatment is included as a component of each remedial alternative for all Land Use Objectives, except the "No Action" alternative. Contaminated groundwater includes Great Miami Aquifer groundwater and perched groundwater. Portions of both are currently being recovered and treated by interim removal actions. The following sections describe the existing and representative treatment systems that are anticipated to be used for treatment of recovered groundwater for safe, environmentally acceptable disposal by discharge from the FEMP to the Great Miami River.

Treatment of Great Miami Aquifer groundwater during remediation would require the construction of new additional facilities as large flow rates are anticipated. Consistent with the two extraction scenarios presented in Section L.9.0, groundwater treatment capacities of 6300 gpm and 7500 gpm would be required to handle maximum extraction system pumping rates for the MCL (20 ppb) and 10^{-6} risk level (3 ppb) Great Miami Aquifer clean-up goals, respectively. Available capacity in existing interim treatment systems and the Advanced Wastewater Treatment (AWWT) Facility would be used, on an interim basis, to treat a portion of the current recovery flow from the South Groundwater Contamination Plume (South Plume).

Existing low-flow and interim systems at the FEMP are currently used to treat extracted perched groundwater for removal of volatile organic compounds (VOCs) and uranium. Beginning in 1995, the newly constructed AWWT Facility will provide permanent treatment for perched groundwater. No additional treatment facilities are contemplated to address perched groundwater treatment as the AWWT Facility capacity is considered sufficient.

Wastewater Treatment, for other than groundwater, is also included as a component of each remedial alternative for all Land Use Objectives, except the "No Action" alternative. Contaminated wastewater includes those generated by site remediation activities, controlled storm water runoff, and baseline wastewater generated by routine site operations. The following sections describe the treatment systems that are anticipated to be used for treatment of these wastewaters for safe, environmentally acceptable disposal by discharge from the FEMP to the Great Miami River. Final treatment of these wastewaters would be performed in the AWWT Facility that is scheduled to be operational in early January 1995. No additional treatment facilities, other than possible source pretreatment, are contemplated to address wastewater treatment.

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L.10.2 INFLUENT CHARACTERISTICS

This section presents a summary level discussion on the characteristics of:

- Recovered Great Miami Aquifer Groundwater
- Recovered Perched Groundwater
- Remediation Wastewater
- Existing Controlled Storm Water Runoff
- Baseline Wastewater

L.10.2.1 Great Miami Aquifer Groundwater

Great Miami Aquifer groundwater contamination plumes exist underneath FEMP property (Waste Pits Area, South Field, and Former Production Area) and underneath off-property area south of the FEMP (South Groundwater Contamination Plume [South Plume]). As described in the Great Miami Aquifer extraction component description, Section L.9.0, a representative method of recovering groundwater from these plumes is the implementation of recovery (extraction) well systems. Four recovery well systems would be used. The total combined recovery flow rate from these systems is projected to range between 6300 and 7500 gpm (maximum), which includes 1500 gpm as currently exists from the South Plume recovery system (FEMP Removal Action #3).

The maximum concentration of uranium contamination in these plumes ranges up to about 1100 ppb Total Uranium; a lower concentration of uranium is anticipated in the combined influent of a groundwater treatment facility. Based on modeling, the average Uranium-238 concentration ($\approx$ Total Uranium concentration) of the recovered groundwater from each of these recovery well systems has been estimated. These estimated concentrations and system flow rates (at 6300 gpm total flow rate) are shown on Table L.10-1.

Other COCs anticipated in recovered Great Miami Aquifer groundwater include other radionuclides (neptunium-237, radium-226, and technetium-99), heavy metals, arsenic, iron, manganese, and organics. Loading curves of the anticipated concentrations of constituents of concern (COCs) entering the groundwater treatment facility from each recovery well system are provided in Appendix F.

Anticipated characteristics of the Great Miami Aquifer groundwater influent to a groundwater treatment facility are summarized in Table L.10-2.

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TABLE L.10-1

GREAT MIAMI AQUIFER GROUNDWATER TREATMENT INFLUENT STREAM URANIUM CONCENTRATIONS (AVERAGE)*

Recovery Well System	Pumping Rate (gpm)	Uranium-238 (≈Total Uranium) Concentration (ppb) Years of recovery 0	5	10	15	20	25	30
System 1	1280	No pump	26.7	16.0	10.8	8.0	5.0	2.9
System 2	3280	No pump	91.5	41.4	27.8	21.1	11.7	7.6
System 3	240	No pump	19.0	11.9	9.1	7.5	5.8	4.6
System 4	1500	4.7	18.5	14.4	9.2	6.1	3.9	2.5
Total Weighted Average	6300	4.7	58.2	28.7	19.2	14.4	8.2	5.3

* Average concentrations in recovered groundwater will be less than measured plume concentrations due to dilution associated with inherent recovery of adjacent non-contaminated groundwater.

TABLE L. 10-2

GREAT MIAMI AQUIFER GROUNDWATER TREATMENT SUMMARY OF ANTICIPATED INFLUENT CHARACTERISTICS

Parameter	Value
Total Uranium	3 - 550 ppb*
Other Radionuclides	Trace
Heavy Metals	Trace
Arsenic	Trace
Iron	1 - 2 ppm
Manganese	0.2 - 1 ppm
Organics (Total)	< 10 ppb
Total Suspended Solids	1 - 9 ppm
Dissolved Oxygen	~ 2 ppm
pH	7 - 8

* The maximum influent uranium concentration would be from the discharge of a single recovery well installed at the area of greatest contamination.

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L.10.2.2 Perched Groundwater

Based on perched groundwater sampling in 1988 and 1989, which identified uranium contamination in the range of 20-700 ppm, removal actions were initiated to pump water from piezometers and extraction wells underneath Plants 2/3, 6, 8, and 9. Pumping from an abandoned clarifier pit at Plant 6, which contains infiltrated water with an initial uranium concentration measurement of about 2000 ppm, was also included with the Plant 6 removal action. The objective of pumping from these wells is the reduction of the hydrostatic head of the associated perched water lenses to reduce the potential for migration of contaminants into the Great Miami Aquifer. In 1994, the FEMP also initiated pumping of contaminated (with VOCs), infiltrated water from four sumps located in the basement of Plant 6. The combined average flow rate from all of these pumping sources is about 10 gpm.

These extracted waters were initially routed through existing FEMP wastewater treatment facilities for uranium removal prior to discharge from the FEMP. In 1990, further analysis of the perched groundwater indicated the presence of VOCs (50-8000 ppb), primarily Trichloroethene, 1,1-Dichloroethene, 1,1-Dichlorothane, 1,2-Dichlorethene, 1,1,1-Trichloroethane, and Tetrachlorethene. The FEMP subsequently initiated VOC removal by installing carbon adsorption (Plant 8 VOC Treatment System) prior to treatment for uranium removal. Beginning in 1995, these and future perched groundwater streams will be routed to the newly constructed AWWT Facility for VOC and uranium removal.

These perched groundwaters are also contaminated at low or trace concentrations with thorium, aluminum, chromium, silver, iron, manganese, and cadmium. Initial analysis of perched groundwater from Plant 2/3 indicated contamination with tributyl phosphate (TBP) of ~100 ppb, but TBP has not been detected in recent years.

Operation of these pumping systems would continue until final remedial actions are implemented. The final remedial actions would likely include excavation of the associated contaminated soils and treatment of the perched groundwater (see Soil Excavation component description, Section L.1.0).

The characteristics of the perched groundwater zones are described in Appendix F. A representative method of remediating these contaminated perched groundwater zones is described as groundwater extraction. Modeling performed in support of this Feasibility Study has concluded that perched groundwater extraction, using passive trenches and drains requires long remediation times (greater than 100 years) for most contaminants. Other options, either alone or in combination with passive collection systems, may provide more rapid and effective remediation. For example, excavation (to eliminate the permeable lenses containing the perched water) is expected to be a more straightforward, rapid, and effective method of removing the contamination and has been adopted as

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the representative option for addressing perched groundwater remediation. Perched groundwater collected during dewatering of the excavations would be removed by pumping and directed to the AWWT Facility for treatment. The flow rate of this perched groundwater transferred to the AWWT Facility is anticipated to be about 10 gpm.

Anticipated characteristics of the perched groundwater influent to the AWWT Facility are summarized in Table L.10-3.

L.10.2.3 Remediation Wastewaters

The FEMP operable units will generate process wastewaters, additional perched groundwater from dewatering activities, and additional (beyond existing) storm water runoff as a result of remediation activities. The contaminants associated with these remediation wastewaters are:

- Uranium
- Low concentrations of thorium
- Low or trace concentrations of other radionuclides
- Low or trace concentrations of heavy metals
- Low or trace concentrations of organics
- Other pollutants regulated by NPDES

Preliminary conceptual information has been used to estimate the quantities and characteristics of these wastewater streams. The anticipated quantities of these wastewater streams are summarized on Table L.10-4. Following Table L.10-4 are general descriptions of these wastewater streams.

- *Operable Unit 1* consists of remediation of the FEMP Waste Pit Area. Generation of significant quantities of wastewater associated with the following remedial activities are expected: initial removal of pit water, removal and processing of pit wastes, and excavation dewatering activities. Wastewater would be recycled back into the remedial process as possible; bleed streams would be discharged for final wastewater treatment. Treated or slightly contaminated water (untreated South Plume groundwater, for example) from Operable Unit 5 groundwater/wastewater treatment facilities may be used for Operable Unit 1 process water to reduce the net volume of final wastewater discharged.

- *Operable Unit 2* consists of remediation of the FEMP Solid Waste Landfill, Lime Sludge Ponds, Active and Inactive Flyash Piles, and the South Field. Generation of small quantities of wastewater associated with the following remedial activities are expected: initial removal of pond water, removal and processing of associated wastes, excavation dewatering activities, and additional surface water controls.

TABLE L.10-3

PERCHED GROUNDWATER
SUMMARY OF ANTICIPATED CHARACTERISTICS

Parameter	Value
Flow Rate	10 - 20 gpm
Total Uranium	15 - 700 ppm
Thorium	20 - 60 ppb
Other Radionuclides	Trace
Trichlorethene	5 - 8000 ppb
1,1-Dichloroethene	5 - 100 ppb
1,2-Dichloroethene	Trace - 30 ppb
1,1-Dichloroethane	Trace - 120 ppb
1,1,1-Trichloroethane	Trace - 130 ppb
Tetrachlorethene	0 - 250 ppb
Aluminum	0.5 - 16 ppm
Cadmium	5 - 150 ppb
Chromium	0.1 - 4 ppm
Silver	0.5 - 2 ppm
Iron	0.7 - 1 ppm
Manganese	0.5 - 4.5 ppm
Total Suspended Solids	50 - 1750 ppm
pH	6.2 - 7.3

TABLE L.10-4

REMEDIATION WASTEWATER
SUMMARY OF ANTICIPATED FLOW RATES*

Operable Unit	Flow Rate (gpm)
1	10 - 250
2	10 - 20
3	10 - 50
4	5 - 15
5	20 - 100

* Excluded are flows from the Great Miami Aquifer, existing perched groundwater, existing controlled storm water runoff, and baseline FEMP wastewater.

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- *Operable Unit 3* consists of remediation of the FEMP Former Production Area. Generation of moderate quantities of wastewater associated with decontamination and dismantlement of facilities, structures, and components is expected. Operable Unit 3 will also generate wastewater from waste processing and from any additional surface water controls. A portion of this activity is currently underway with the implementation of Operable 3 removal actions.

- *Operable Unit 4* consists of remediation of Silos 1, 2, 3, and 4 and the associated silo facilities. Generation of small quantities of wastewater associated with the following remedial activities are expected: removal and processing of associated wastes, excavation dewatering activities, and any additional surface water controls.

- *Operable Unit 5* consists of remediation of environmental media - soils, groundwater, surface water, sediments, flora, and fauna. Table L.10-4 does not include Great Miami Aquifer and perched groundwater influents, existing controlled storm water runoff, or baseline wastewater. Table L.10-4 does include the wastewater generated by the following anticipated remediation activities: excavation, dewatering of excavations, recovered water from any underdrain systems or interim storage system sumps, and surface water controls associated with construction of remediation facilities.

The primary contaminant of concern associated with these wastewater streams is uranium. Other contaminants of lesser concern that would be addressed by pretreatment or the AWWT Facility include other radionuclides, heavy metals, organics, and other NPDES-related pollutants. Pretreatment may be implemented by the individual operable units remedial systems, as required, prior to final treatment at the AWWT Facility.

L.10.2.4 Existing Controlled Storm Water Runoff

Figure L.10-1 illustrates the areas of the FEMP that are currently controlled for storm water runoff collection. Characteristics of the existing storm water runoff influent that will be treated by the newly constructed AWWT Facility are summarized in Table L.10-5. Following the table is a description of the current FEMP storm water runoff influents that require treatment prior to discharge from the FEMP. As site areas are remediated, these influents will diminish, and the associated collection and treatment systems may be progressively decommissioned and removed.

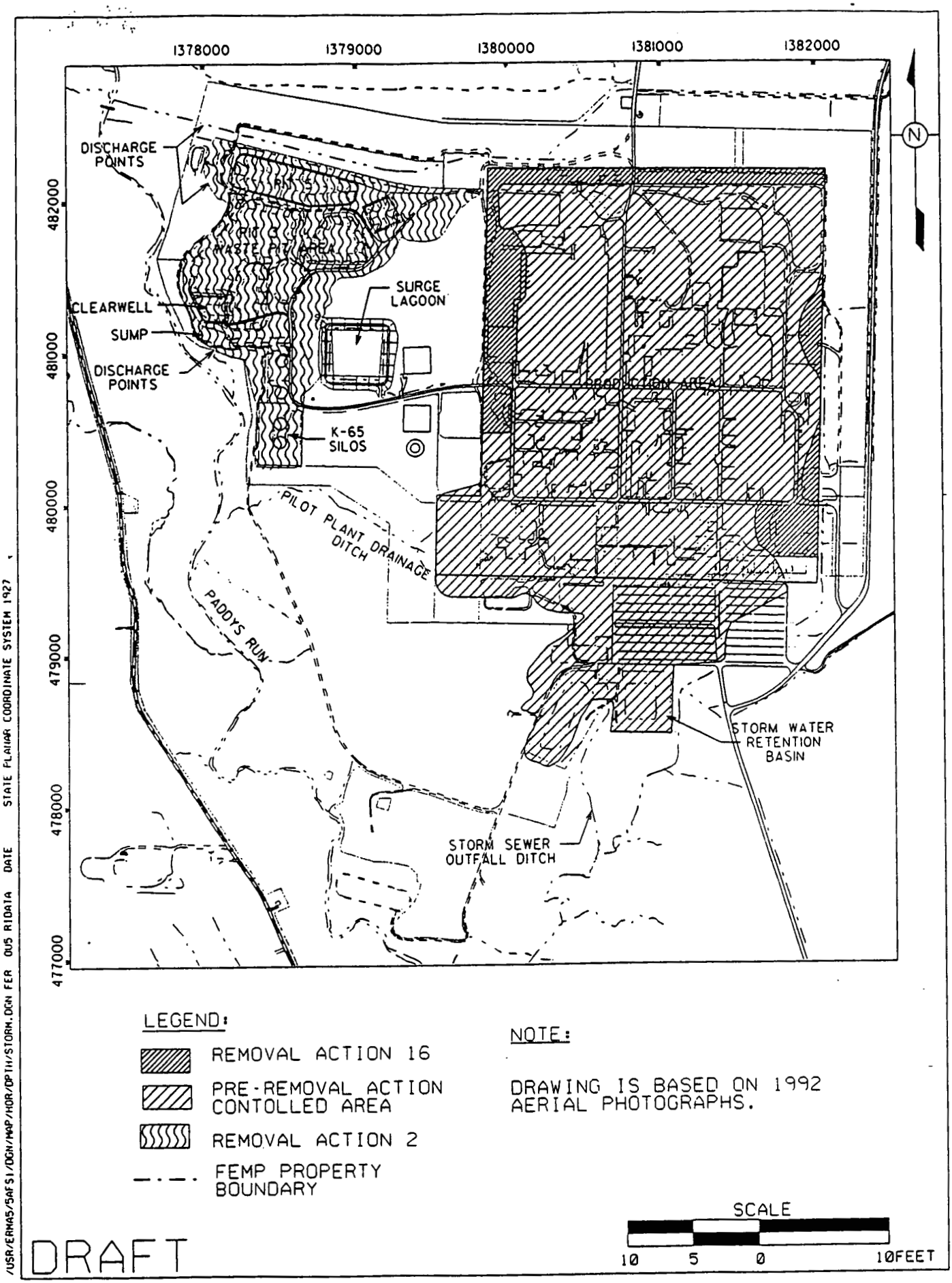

FIGURE L.10-1. AREA OF CONTROLLED STORM WATER RUNOFF

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TABLE L.10-5
EXISTING SURFACE/STORM WATER RUNOFF SUMMARY OF ANTICIPATED CHARACTERISTICS

Parameter	Former Production Area & Parking Lots Value	Waste Pit Area & Perimeter Value
Flow Rate	100 - 700 gpm	20 - 40 gpm
Total Uranium	0.3 - 1.5 ppm	0.5 - 3.5 ppm
Other Radionuclides	Low or Trace	Low or Trace
Heavy Metals	Trace	Trace
Organics	Trace	Trace
Total Suspended Solids	20 - 300 ppm	20 - 300 ppm
pH	7 - 10	7 - 10

Surface and storm water runoff from the former production area and perimeter areas, including parking lots, is collected by a sitewide storm sewer system. This runoff is collected in a ten million-gallon Storm Water Retention Basin (SWRB), located in the southeast quadrant of the site, for settling prior to discharge from the FEMP. The average anticipated storm water runoff flow rate is approximately 215 gpm. However, since flow into the SWRB occurs mostly during rainfall events, a larger SWRB discharge flow rate is required to prevent SWRB overflow. A 700 gpm discharge flow rate has been determined to be adequate to prevent overflow under severe or successive heavy rainfall events; therefore, the SWRB pumping system was sized for a maximum flow rate of 700 gpm. The uranium concentration in the discharge from the SWRB typically ranges between 300-1200 ppb (average of about 900 ppb).

Currently, up to 300 gpm of the SWRB discharge is treated for uranium removal by the Interim Advanced Wastewater Treatment unit at the SWRB - IAWWT(SWRB). The remainder of the flow is routed through the new South Plume discharge line to the Great Miami River via the FEMP outfall line. Beginning in 1995, the total discharge will be routed to the newly constructed AWWT Facility for treatment prior to discharge from the FEMP.

The Biodenitrification (BDN) Surge Lagoon receives storm water runoff from the following sources: Waste Pit Area storm water runoff collected in the Clearwell, Waste Pit Area Perimeter stormwater runoff collected in a concrete sump, and Pit 6 storm water runoff (normally contained in the pit, but requiring occasional pump out).

L.10.2.5 Baseline FEMP Wastewater

The FEMP currently generates approximately 30 - 60 gpm of contaminated wastewater, in addition to the controlled storm water runoff described above, during routine operations. Characteristics of the combined "baseline" contaminated wastewaters are summarized in Table L.10-6. A general description of the baseline FEMP wastewater follows the table.

TABLE L.10-6
BASELINE FEMP WASTEWATER
SUMMARY OF ANTICIPATED CHARACTERISTICS

Parameter	Value
Flow Rate	30 - 60 gpm
Total Uranium	0.5 - 3.5 ppm
Other Radionuclides	Low or Trace
Heavy Metals	Trace
Organics	Trace
Total Suspended Solids	20 - 300 ppm
pH	7 - 10

FEMP baseline wastewater is generated from the following sources: FEMP laboratory, controlled pad storm water runoff, garage floor washing, general decontamination (Building 69), incidental plant usage (i.e., condensate, cleaning, etc.), laundry facilities, boiler plant blowdown, coal pile runoff, and filter backwash from the SPIT and IAWWT systems. These wastewaters are collected at the General Sump or Plant 8 Sump.

Additionally (not included in Table L.10-6), the FEMP generates wastewater that is considered non-contaminated (less than 20 ppb uranium). These wastewaters are generated from the following sources: personnel showers, lime sludge ponds decant, water treatment plant, boiler water treatment, and sanitary sewage. Sanitary sewage is routed to the FEMP Sewage Treatment Plant for treatment prior to discharge from the FEMP. The other streams are routed to the "clean-side" General Sump for monitoring and treatment, if necessary to meet National Pollutant Discharge Elimination System (NPDES) permit requirements, prior to discharge from the FEMP.

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L.10.2.6 AWWT Facility Influent

The AWWT Facility will provide final treatment of the above described influents - contaminated perched groundwater, remediation-generated wastewater, controlled storm water runoff, and baseline wastewater (exclusive of non-contaminated flows) - prior to discharge to the Great Miami River. A summary of the anticipated combined AWWT influent characteristics is provided in Table L.10-7. Table L.10-7 does not address the interim South Plume groundwater treatment to be provided by the AWWT Facility, as described in the following section.

TABLE L.10-7
AWWT FACILITY
SUMMARY OF ANTICIPATED INFLUENT CHARACTERISTICS

Parameter	Phase I (Influent from SWRB) Value	Phase II (Other Influents) Value
Flow Rate	100 - 700 gpm	50 - 400 gpm
Total Uranium	0.3 - 1.5 ppm	0.3 - 5 ppm
Other Radionuclides	Low or Trace	Low or Trace
Heavy Metals	Trace	Trace
Volatile Organics	Trace	5 - 200 ppb
Other Organics	Trace	Trace
Total Suspended Solids	20 - 300 ppm	20 - 300 ppm
pH	7 - 10	7 - 10

L.10.3 TREATMENT STRATEGY

This section presents a discussion on the operational strategy planned for treatment of contaminated FEMP groundwater and wastewater. The strategy involves interim measures to address uranium discharge reduction prior to the implementation of permanent groundwater treatment, as well as the permanent long-term measures. Figure L.10-2 illustrates the existing and planned Interim FEMP Groundwater and Wastewater Flow Diagram. Figure L.10-3 illustrates the final Remedial Action FEMP Groundwater and Wastewater Flow Diagram (during site remediation).

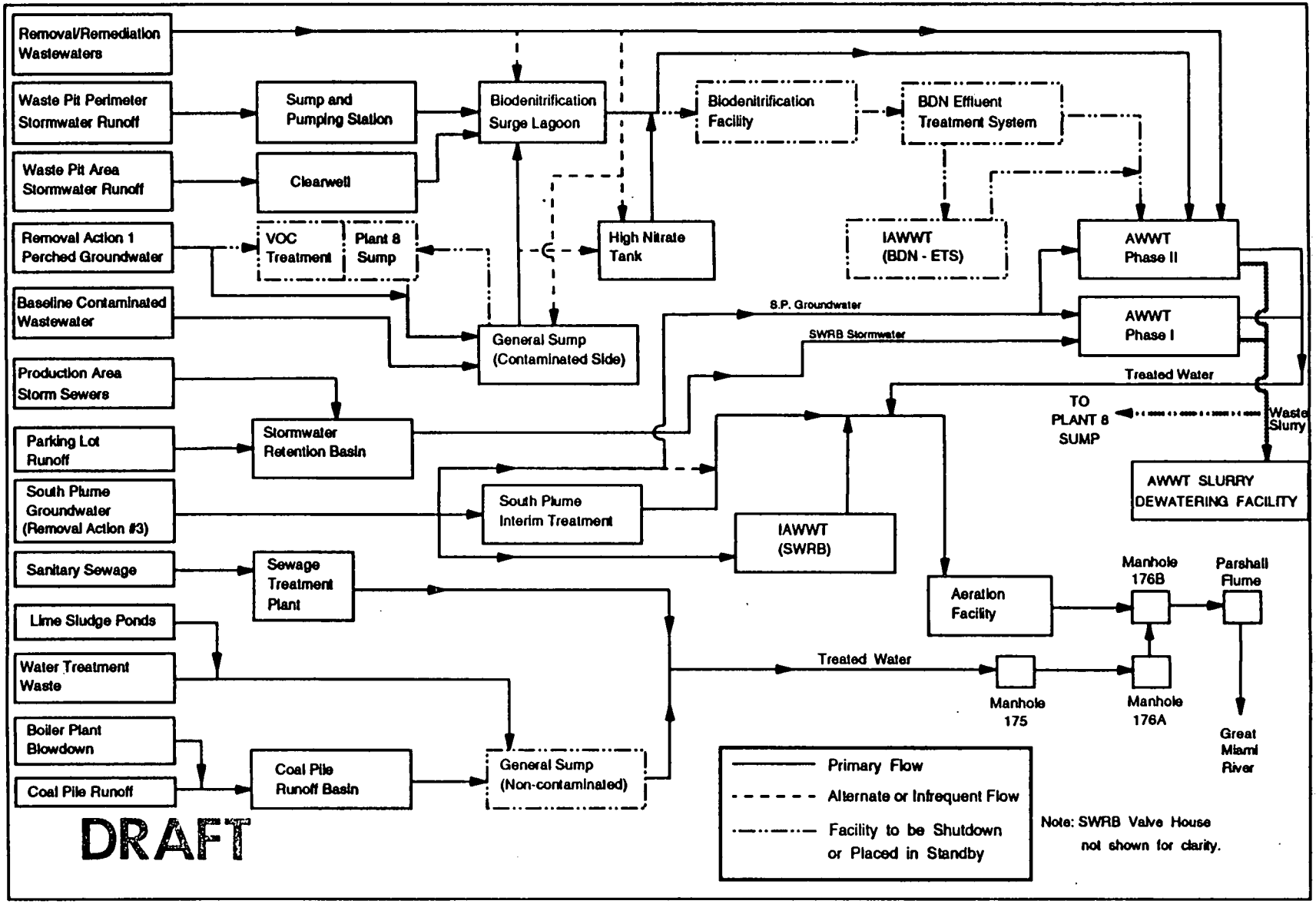

FIGURE L.10-2. INTERIM FEMP GROUNDWATER AND WASTEWATER FLOW DIAGRAM

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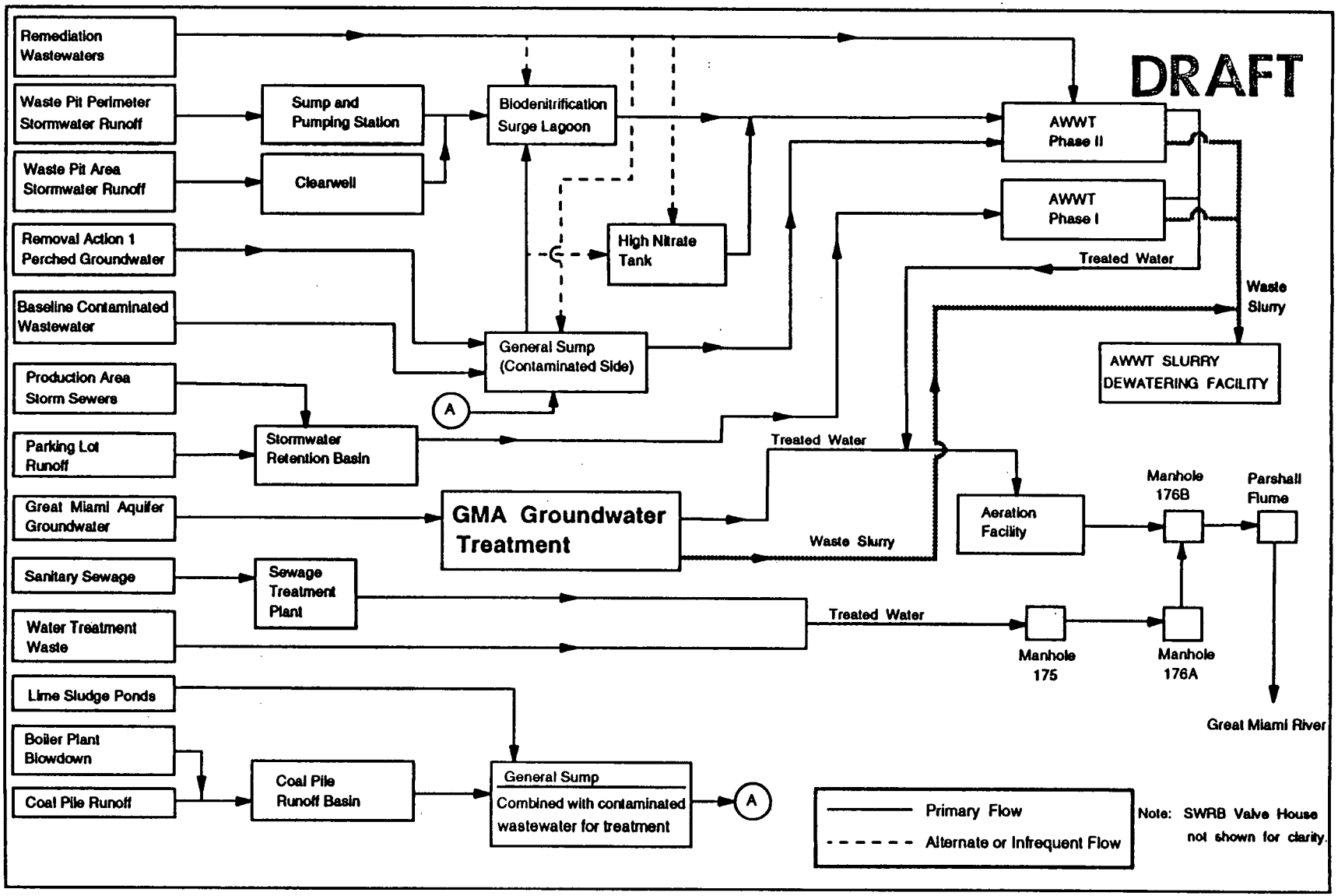

FIGURE L.10-3. REMEDIAL ACTION FEMP GROUNDWATER AND WASTEWATER FLOW DIAGRAM

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L.10.3.1 Interim Great Miami Aquifer Groundwater Treatment

A portion of Great Miami Aquifer groundwater, recovered from the South Plume, will be treated for uranium removal to produce effluent uranium concentrations of less than 5 ppb using existing interim systems and the AWWT Facility, as shown in Table L.10-8. This strategy is discussed following the table.

TABLE L.10-8
INTERIM GREAT MIAMI AQUIFER GROUNDWATER TREATMENT

Treatment System	Flow Rate
South Plume Interim Treatment	200 gpm
AWWT Facility	200 - 900 gpm
IAWWT (SWRB)	400 gpm

The installation of the Removal Action #3 (South Groundwater Contamination Plume) IAWWT units at the SWRB and at the BDN-ETS in 1992 has allowed the FEMP uranium discharge (to the Great Miami River) to be maintained below 1700 lb/yr. In 1993, as a result of an Operable Unit 2 dispute resolution agreement, the FEMP initiated a Supplemental Environmental Project (SEP) with the objective of further reducing uranium discharges from the FEMP site to the Great Miami River. The SEP provides the following interim Great Miami Aquifer groundwater treatment operations:

- A South Plume Interim Treatment (SPIT) system was installed to provide interim treatment of 200 gpm of South Plume groundwater until permanent groundwater remediation treatment is provided. The system employs ion exchange for uranium removal. The SPIT system has been in operation since March 1994 and should remain in service at least until a permanent groundwater treatment facility is operational.

- The operating life of the existing IAWWT(SWRB) unit will be extended and the unit will be converted to treat additional South Plume groundwater instead of storm water. The total treatment capacity of the unit will be increased from 300 gpm to 400 gpm (following start-up of the AWWT Facility, scheduled for early 1995).

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- The AWWT - Phase I Facility will be used for treatment of South Plume groundwater when minimal storm water is available for treatment (roughly 70 percent of a typical year). The annual average groundwater treatment flow rate will be about 500 gpm. This provision will be implemented when the AWWT Facility becomes operational in early 1995.

- The SEP will also eliminate the previously scheduled treatment of low-uranium (less than 20 ppb) wastewater streams by the AWWT - Phase II Facility. The resulting freed AWWT treatment capacity will be used to treat 200 gpm of South Plume groundwater. This provision will be implemented when the AWWT Facility becomes operational in early 1995.

The effluent from these interim groundwater treatment operations, as well as the untreated portion of the South Plume discharge, is routed to the SWRB Valve House. From the Valve House, these effluents flow to the Effluent Aeration Facility for aeration to ensure the dissolved oxygen concentration is greater than 5 ppm. Downstream of the Effluent Aeration Facility, the treated groundwater/wastewater is combined at Manhole 176B with non-contaminated wastewater and treated Sewage Treatment Plant effluent from Manhole 175. These combined flows will pass through a parshall flume and outfall monitoring station for FEMP discharge flow measurement and monitoring.

L.10.3.2 Great Miami Aquifer Groundwater Treatment During Site Remediation

Treatment of Great Miami Aquifer groundwater during site remediation would require the construction of new additional treatment facilities as additional recovery well systems are proposed. The maximum flow rate of recovered Great Miami Aquifer groundwater is projected to be between 6300 and 7500 gpm. The treatment strategy would be based on the uranium concentration in the aquifer at each well or well system. The proposed strategy is to provide treatment of Great Miami Aquifer groundwater recovered from areas of the aquifer that contain uranium concentrations greater than 20 ppb or 3 ppb, depending upon the selected remedial alternative.

Preliminary modeling results indicate the following groundwater treatment scenarios are required to support the extraction scenarios:

1) 6300 gpm capacity for 30 years.
2) 7500 gpm capacity for 75 years.

Both of these treatment scenarios for the Groundwater Treatment component will be cost estimated; however, all descriptions that follow relate to the 6300 gpm scenario, which will be implemented in 2100 gpm modules.

The primary objective of groundwater treatment is to produce an effluent uranium concentration of less than 5 ppb; however, concentrations of less than three ppb are anticipated. Effluent concentrations of other contaminants will be maintained below MCL concentrations. Also, required effluent NPDES characteristics shall be maintained.

Treated and untreated Great Miami Aquifer groundwater will be discharged from the FEMP to the Great Miami River via the existing outfall discharge piping and Effluent Aeration Facility (recently installed as part of Removal Action #3) and monitoring systems.

L.10.3.3 Interim Perched Groundwater Treatment

The existing Plant 8 VOC Treatment System provides filtration and carbon adsorption processing prior to gross uranium removal by chemical precipitation and filtration at the Plant 8 Sump. VOC concentrations are reduced to less than 5 ppb; the uranium concentration is reduced to less than 0.0004 lb/gal (48 ppm). From the Plant 8 Sump, the treated wastewater is directed to the General Sump for further disposition as described below. In 1995, perched groundwater will be diverted to the AWWT Facility for treatment, which will allow decommissioning of the outmoded Plant 8 facility thereafter. Treatment at the AWWT Facility will result in effluent VOC concentrations of less than 5 ppb and uranium concentrations of less than 5 ppb.

L.10.3.4 Interim Wastewater Treatment

Treatment of contaminated removal action and remediation wastewaters, controlled storm water runoff, and baseline wastewaters will be performed using the following existing (or soon-to-be-constructed) facilities:

- General Sump
- Plant 8 Sump
- Biodenitrification (BDN) Surge Lagoon
- BDN High Nitrate Tank
- BDN Facility
- BDN Effluent Treatment System (ETS)
- IAWWT(BDN-ETS)
- Storm Water Retention Basin (SWRB)
- IAWWT(SWRB)
- AWWT Facility

Removal action and remediation wastewaters will be fed to the most convenient, technically acceptable receiving facility - General Sump, Plant 8 Sump, BDN Surge Lagoon, BDN High Nitrate Tank, or AWWT Facility. Waste Pit Area storm water runoff is collected in the BDN Surge Lagoon.

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Former Production Area and parking lot storm water runoff is collected in the SWRB. Baseline wastewaters are collected at the General Sump or Plant 8 Sump. A major portion of the total FEMP wastewater streams will receive final treatment at interim ion exchange systems to produce effluent uranium concentrations of less than 5 ppb. Beginning in 1995, these wastewaters will be treated at the AWWT Facility to produce effluent uranium concentrations less than 5 ppb, as well as reduction of other contaminants (i.e., other radionuclides, heavy metals, organics, etc.). Source pretreatment may be implemented, if necessary, prior to introduction into the associated final treatment systems.

The General Sump currently receives both contaminated and non-contaminated wastewater streams for treatment and/or diversion to Plant 8, the BDN Surge Lagoon or High Nitrate Tank (HNT), or discharge to the Great Miami River. Uranium-contaminated wastewaters are segregated, based primarily on the source of the wastewater and its uranium content. Segregation may also be based on other contaminants and the source of the wastewater. Prior to operation of the AWWT Facility, heavily uranium-contaminated wastewaters (greater than 0.0004 lb/gal), and other streams that required chemical precipitation and filtration, were routed to the Plant 8 Sump for additional treatment. After treatment at Plant 8, filtrate is returned to the General Sump for sampling and eventual transfer to the BDN Surge Lagoon or HNT.

The Plant 8 Sump will remain in operation to accommodate certain FEMP removal and remedial actions at least through 1995. As the AWWT Facility becomes operational and performance-proven, wastewater streams will subsequently be rerouted from Plant 8 to the AWWT Facility. Minor system modifications will be required for rerouting the wastewater streams. Miscellaneous waste slurries and sludges, typically dewatered at Plant 8, will be rerouted to the AWWT Slurry Dewatering Facility when it becomes operational in late 1995.

The BDN Surge Lagoon collects wastewater from the General Sump as well as Waste Pit Area controlled storm water runoff. The combined flow from the BDN Surge Lagoon and from the associated HNT, maximum of about 200 gpm, is currently directed to the BDN and BDN Effluent Treatment facilities prior to discharge from the FEMP.

The HNT will remain in service until Operable Unit 3 Thorium Nitrate and UNH removal actions are completed to provide a method for blending in high nitrate concentration wastewaters to the BDN Facility. The HNT would remain in service thereafter to support flow equalization for influent to the AWWT Facility. At a minimum, Operable Unit 4 plans to employ the HNT for equalization of generated wastewaters prior to discharge to the AWWT Facility.

The BDN Facility was designed for the purpose of reducing nitrates in wastewater. The BDN Facility will remain in service to provide nitrate reduction in wastewaters generated by Operable Unit 3 removal action activities, which are expected to be essentially completed in late 1995. Thereafter, the BDN Facility would be placed in standby until all site activities associated with nitrate-bearing wastewaters are completed, at which time the facility may be decommissioned. The BDN Surge Lagoon discharge will then be routed directly to the newly constructed AWWT Facility for treatment prior to discharge from the FEMP.

The BDN-ETS provides final treatment of the BDN wastewater before it is discharged. Its primary function is to reduce the total suspended solids (TSS) and biochemical oxygen demand (BOD) levels in the effluent from the BDN Facility. The BDN-ETS will remain in service as long as the BDN Facility service is maintained; thereafter, the system may be converted for use as a site sanitary (sewage) treatment system to replace the old existing FEMP sewage treatment plant, which could then be decommissioned.

Currently, up to 100 gpm of the BDN Facility effluent is treated for uranium removal by the Interim Advanced Wastewater Treatment unit at the BDN Effluent Treatment System, IAWWT(BDN-ETS). The IAWWT(BDN-ETS) will likely be decommissioned shortly after the AWWT Facility becomes operational, unless a viable alternative for its use is identified.

The SWRB will remain in service to collect storm water runoff for flow equalization prior to treatment at the AWWT Facility. The SWRB would likely remain in service beyond the year 2020 to support site remediation. The SWRB can be decommissioned upon satisfactory site remediation that eliminates the need to collect site storm water runoff.

The IAWWT (SWRB) was installed as an interim treatment unit for storm water. Beginning in early 1995, SWRB discharge will be treated by the AWWT Facility. The IAWWT(SWRB) will remain in operation after the AWWT Facility becomes operational, at which time the unit capacity will be increased to 400 gpm and will be used to treat a portion of the recovered South Plume groundwater flow until permanent groundwater treatment facilities are operational.

The AWWT Facility is scheduled to be operational in early 1995 to provide final treatment of all site contaminated storm water runoff and wastewater. The facility will have a total treatment capacity of 1100 gpm - 700 gpm for storm water runoff (Phase I) and 400 gpm for other wastewater (Phase II). It will also provide perched groundwater treatment and will supplement interim South Plume groundwater treatment, as previously described. The AWWT Facility will remain in service

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throughout site remediation and will be one of the final site facilities to be decommissioned and dismantled.

The effluent from the AWWT Facility (less than 5 ppb uranium) will be routed to the SWRB Valve House. From the Valve House, the effluent, as well as those from the South Plume discharge and interim groundwater treatment systems, flows to the Effluent Aeration Facility for aeration to ensure the dissolved oxygen concentration is greater than 5 ppm. Downstream of the Effluent Aeration Facility, the treated groundwater/wastewater is combined at Manhole 176B with non-contaminated wastewater and treated Sewage Treatment Plant effluent from Manhole 175. These combined flows will pass through a parshall flume and outfall monitoring station for FEMP discharge flow measurement and monitoring.

A waste slurry/sludge dewatering system (AWWT Slurry Dewatering Facility) is planned to be installed adjacent to the AWWT Facility. The primary purpose of the new AWWT Slurry Dewatering Facility is the processing (dewatering) of waste slurries and sludges from the AWWT Facility and those generated from future groundwater remediation treatment; the dewatering of miscellaneous site waste sludges may also be performed at this new facility. The dewatered waste material will be packaged for on-site or off-site disposal. Construction completion is scheduled for October 1995. The AWWT Slurry Dewatering Facility will remain in service as long as the AWWT Facility and groundwater treatment facilities remain in service.

L.10.3.5 Perched Groundwater and Wastewater Treatment

In general, perched groundwater and wastewater treatment during site remediation will be accomplished as previously described for the interim period prior to site remediation. Several interim and outmoded facilities - Plant 8 Sump, BDN Facility, IAWWT units - will either be shutdown or placed on standby. Facilities used to collect and manage wastewater for subsequent routing to the AWWT Facility will be phased out as site remediation eliminates the associated wastewater generation.

As previously described, source pretreatment may be implemented prior to final treatment at the AWWT Facility. All perched groundwater and wastewater will be treated at the AWWT Facility to produce effluent uranium concentrations less than 5 ppb, as well as to reduce other contaminants (i.e., other radionuclides, heavy metals, organics, etc.). Effluent concentrations of other contaminants will be maintained below MCL concentrations. Required effluent NPDES characteristics shall be maintained.

L.10.3.6 Estimated Uranium Discharge to the Great Miami River

Figure L.10-4 provides a plot of the estimated annual uranium discharge from the FEMP to the Great Miami River. The plot begins in 1993, the start of South Plume Removal Action 3 groundwater recovery, and ends in 2069, the predicted completion of groundwater remediation under the 10^{-6} risk level (3 ppb) clean-up goal.

L.10.4 TREATMENT SYSTEM DESIGN CONSIDERATIONS

L.10.4.1 Great Miami Aquifer Groundwater Treatment System

Treatment of Great Miami Aquifer groundwater would require the construction of new facilities, as the anticipated maximum recovery flow rate of about 6300 gpm is much greater than the capacity of existing facilities. The primary objective of Great Miami Aquifer groundwater treatment is the reduction of uranium to less than 5 ppb and the reduction of other COCs to less than MCL or proposed MCL concentrations (or to existing Great Miami Aquifer water quality levels if less than MCL). Primary design considerations for these new facilities include the following:

- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs). These include, but are not limited to: the Solid Waste Disposal Act (RCRA), the Safe Drinking Water Act, the Clean Water Act, the Clean Air Act, Occupational Safety and Health Act (OSHA) requirements, DOE requirements, and state and local requirements. Treatment and monitoring capability associated with meeting NPDES requirements is a primary consideration.

- Operating life. The design operational life of the treatment facilities shall be in accordance with the duration of contaminated groundwater recovery. Current groundwater modeling suggests a treatment period of about 30 years.

- Process. The treatment must reduce the concentrations of COCs in the recovered groundwater to acceptable levels prior to discharge to the environment. The treatment must also remove secondary contaminants that could impact adversely the process used to remove the contaminants of concern (for example, contaminants that can foul ion exchange resin).

- Waste management. The treatment must be designed to minimize the associated waste generation. Appropriate waste management concepts (i.e., processing, stabilization, and packaging) shall be incorporated into the design to reduce mobility of the contaminants and to provide safe, proper on-property and off-site management.

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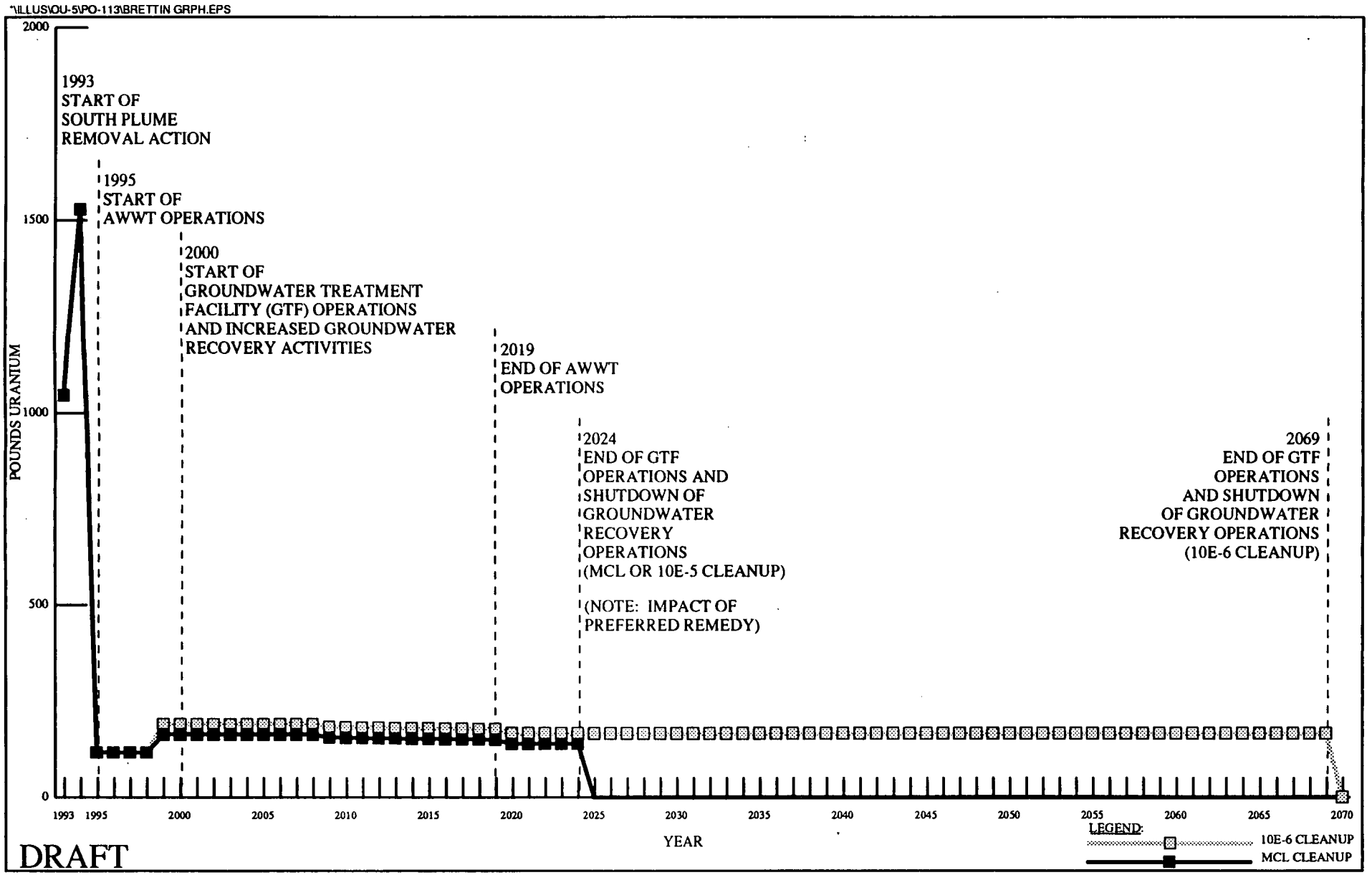

FIGURE L.10-4. ESTIMATED URANIUM DISCHARGE TO THE GREAT MIAMI RIVER

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- Protection of human health and the environment. The design must consider the protection of workers, the public, and the environment from chemical and untreated groundwater releases.

- Implementability and flexibility. The treatment design should consider proven and reliable technologies. The treatment facilities should be readily constructable and designed for ease of operation and maintenance. The design shall consider system modules of equal capacity to accommodate implementation flexibility.

- Capital and operating cost. The cost of construction and operations must be reasonable and amenable to the benefit provided to the public and the environment.

- Future decommissioning and dismantlement. The design must consider the ease, safety, and environmental protection of future decommissioning and dismantlement of the treatment facilities when remediation by treatment is complete.

L.10.4.2 Perched Groundwater Treatment System

The same basic design considerations described above apply to perched groundwater treatment. Because of the greater and more diverse contaminant concentrations in perched groundwater, as compared to Great Miami Aquifer groundwater, the treatment of perched groundwater separate from Great Miami Aquifer groundwater is suggested. The existing Plant 8 VOC Treatment System provides filtration and carbon adsorption processing prior to Plant 8 Sump chemical precipitation and filtration. In 1995, perched groundwater will be diverted to the newly constructed AWWT Facility for treatment, which will allow decommissioning of the outmoded Plant 8 facility.

The primary objectives of perched groundwater treatment are the removals of VOCs and uranium to effluent concentrations of less than 5 ppb each.

L.10.4.3 Wastewater Treatment Systems

The same basic design considerations, as described above, also apply to wastewater treatment. The treatment of the wastewater influents will be accomplished using existing and soon-to-be-constructed FEMP treatment facilities. Beginning in early 1995, final treatment prior to discharge from the FEMP will be accomplished by the AWWT Facility. The primary design considerations for the AWWT Facility included the following:

- Process: The AWWT Facility design was driven by DOE Order 5400.5, "Radiation Protection of the Public and the Environment," which requires the consideration of Best

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Available Technology and reduction of radiation exposure to levels that are "as low as reasonably achievable (ALARA)." The primary goal is the treatment of wastewater to produce an effluent uranium concentration of less than 5 ppb. Additionally, the design provides for reduction of other radionuclides, suspended solids, heavy metals, and organics.

- Capacity: The design treatment capacity was based on existing wastewater generation plus allowance for anticipated site remediation.

L.10.5 EXISTING AND PROPOSED TREATMENT SYSTEM DESCRIPTIONS

Below are descriptions of the existing and proposed treatment systems that are contemplated to address interim and permanent treatment of FEMP groundwater and wastewater. Figure L.10-5 shows the existing and proposed locations of these systems.

L.10.5.1 Great Miami Aquifer Groundwater Treatment Facilities

The permanent Great Miami Aquifer remediation treatment facilities would have a treatment capacity of up to 6300 gpm (see Appendix F). The treatment facilities would be implemented in 2100 gpm modules, with common facilities for chemical handling, regeneration of exhausted ion exchange resin, and processing of waste streams. The modular implementation would allow phased implementation, if necessary, due to potential yearly funding constraints, or allow verification of required capacity before final commitment of resources.

The treatment facilities would be located near the southwest corner of the FEMP site. This location is desirable because of its proximity to the existing South Plume recovery system pipeline, the SWRB Valve House, the effluent discharge pipeline to the Great Miami River, and the AWWT Facility.

The following subsections provide a description of a representative 2100 gpm Great Miami Aquifer groundwater treatment module, including the common ancillary process systems. The description provided is conceptual, and perhaps conservative, and will be refined during detailed design activities. Based on current Great Miami Aquifer groundwater modeling, up to three 2100 gpm modules are assumed to be required for the treatment of contaminated Great Miami Aquifer groundwater. Figure L.10-6 shows the major process operations of one 2100 gpm module and the common ancillary process systems shared by all the Great Miami Aquifer groundwater treatment modules. A list of the major process equipment for one 2100 gpm Great Miami Aquifer groundwater treatment module is given in Table L.10-9.

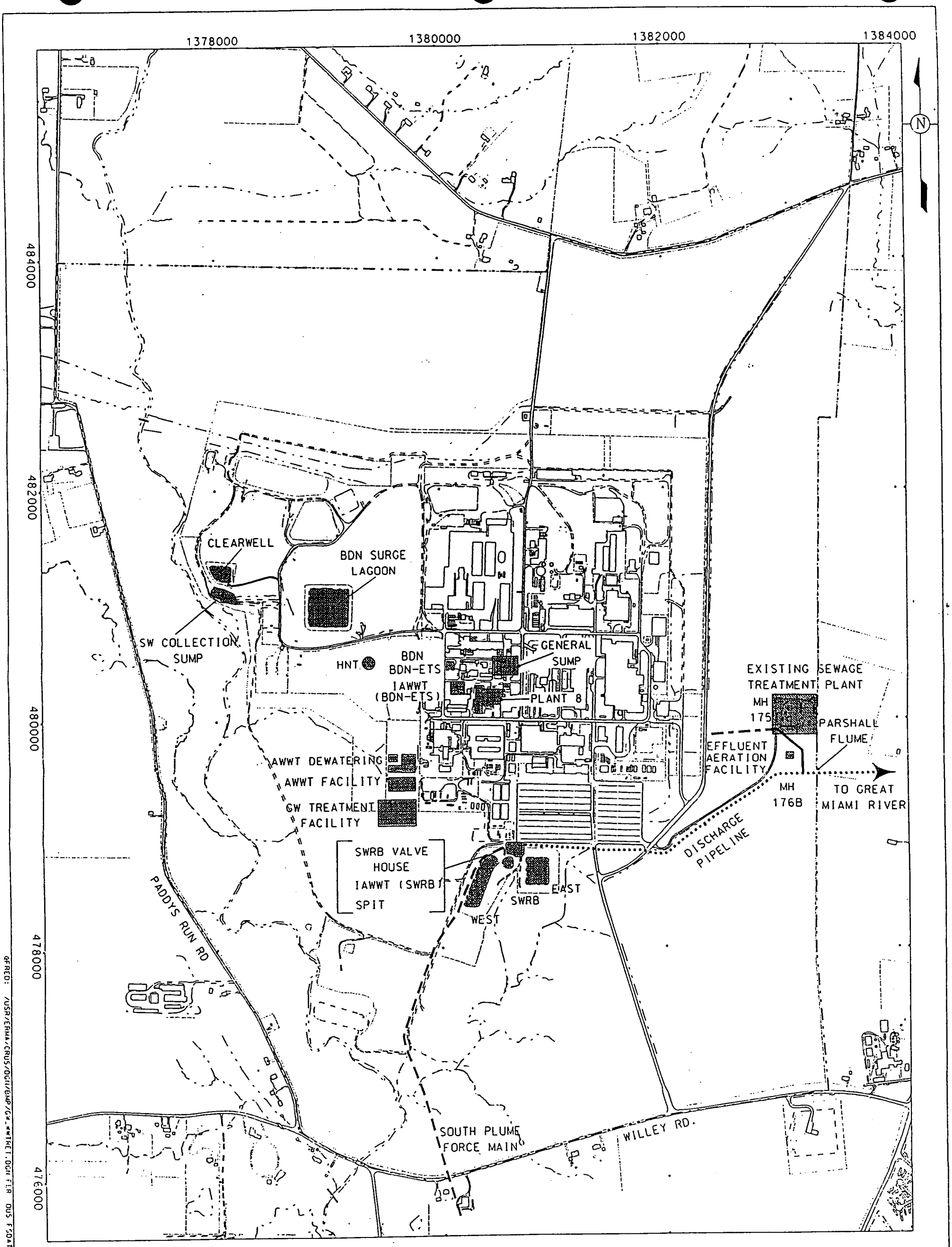

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FIGURE L.10-5. LOCATION OF GROUNDWATER/WASTEWATER TREATMENT SYSTEMS

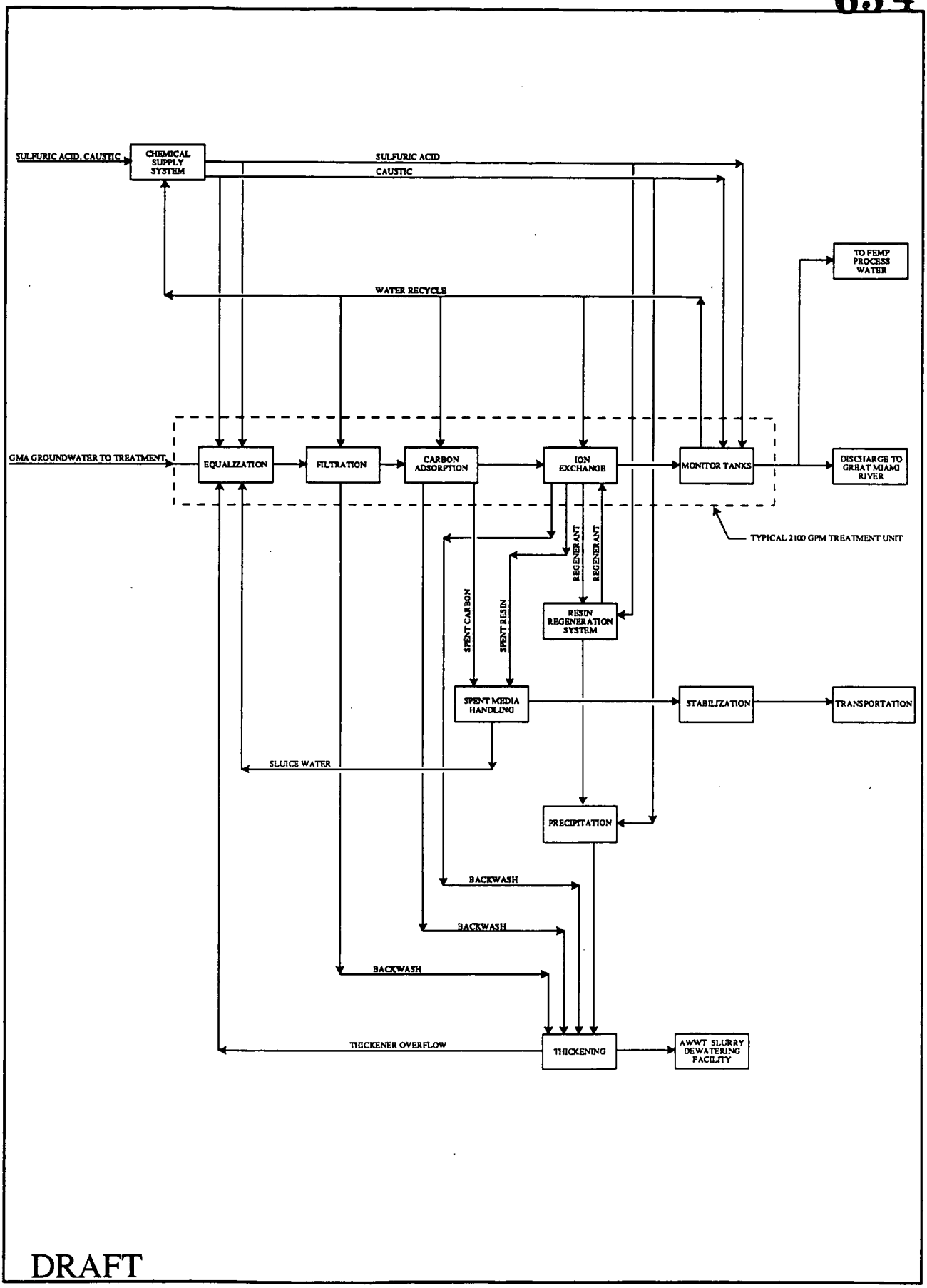

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FIGURE L.10-6. GREAT MIAMI AQUIFER GROUNDWATER TREATMENT BLOCK FLOW DIAGRAM

TABLE L.10-9

GREAT MIAMI AQUIFER GROUNDWATER TREATMENT
2100 GPM MODULE (WITH COMMON EQUIPMENT)

Quantity	Equipment Name	Functional Description
2	Equalization Tank*	Raw groundwater equalization and pH adjustment
1	Sulfuric Acid Day Tank*	Short term acid supply for pH adjustment and resin regeneration
1	Caustic Day Tank*	Short-term caustic supply for pH adjustment, resin regeneration and precipitation
5	Multi-media Filter*	Initial groundwater filtration
2	Bag Filter*	Final groundwater filtration
1	Backwash Surge Tank*	Storage of backwash water containing solids
1	Break Tank*	Intermediate storage for groundwater during treatment
8	Activated Carbon Adsorber*	Organic removal from groundwater
8	Ion Exchange Vessel*	Uranium removal from groundwater
2	Monitor Tank*	Monitoring and pH adjustment of treated groundwater prior to discharge
1	Sulfuric Acid Storage Tank	Bulk acid storage
1	Caustic Storage Tank	Bulk caustic storage
3	Regenerant Tank	Storage for dilute sulfuric acid used to regenerate resin
1	Thickener	Settle solids from backwash water
1	Eluate Storage Tank	Storage of regenerant (eluate) loaded with uranium
1	Waste Slurry Surge Tank	Storage for solids slurry from thickener
2	Precipitator	Treat resin regenerant with caustic to remove uranium as precipitate
3	Spent Media Tank	Storage for exhausted resin and carbon
1	Vendor Solidification Package	Stabilize exhausted resin, carbon, and waste solids
1	Effluent Storage Tank	Storage for treated groundwater from all modules prior to discharge

* Additional 2100 gpm modules would include only those items identified with *.

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Equalization

Groundwater would be received in equalization tanks at each 2100 gpm Great Miami Aquifer groundwater treatment module. If necessary, the pH would be adjusted in these tanks by adding either sulfuric acid or caustic soda. One equalization tank would be agitated and operated continuously. A redundant agitated tank would be provided to ensure continuous operation. The adjusted groundwater would be pumped from the equalization tanks to a filtration system.

Filtration

The filtration system would consist of multi-media filter vessels. Each filter vessel would contain media layers of different densities and sizes ranging from coarse to fine. Each multi-media filter vessel would be periodically backwashed when high differential pressure is experienced across the filter media. After multi-media filtration, the groundwater would be routed to bag filters for final filtration.

Adsorption

After filtration, the groundwater would be pumped to an activated carbon adsorption system that would remove possible organic contaminants. Regeneration of spent activated carbon by vendors is not assumed due to the associated radioactive contamination. The spent activated carbon would be sluiced to the spent media tank for holding prior to processing, including stabilization if necessary, and disposal.

On-site or vendor-site carbon regeneration would be investigated before or during detailed design of the treatment facilities. The need to provide full system treatment capability for organic contaminants would also be further investigated prior to or during detailed design as currently available data does not indicate a significant concentration of organics. This treatment capability will be provided for the first 2100 gpm module regardless.

Ion Exchange

After activated carbon adsorption, the groundwater would be treated by an ion exchange system for uranium removal. The system would consist of a train, or series of vessels, piped in parallel with other trains of vessels. The parallel train configuration would allow regeneration or standby of a train while the others remain on-line. Dowex 21K™ resin, which was developed specifically for uranium removal and has proven to be successful in FEMP interim treatment systems, would be used. At the end of the resin's useful life, it would be sluiced to the spent media tank for holding prior to processing, including stabilization if necessary, and disposal.

Effluent Monitoring

After treatment by the ion exchange system, the groundwater would be pumped to monitor tanks. The pH and uranium concentration would be monitored in these tanks to verify that the treated groundwater is suitable for discharge or reuse as process water at the FEMP. Treated groundwater which does not meet the discharge requirements would be returned to the equalization tanks for reprocessing. Acceptable effluent discharge would be pumped from the treatment facility to the SWRB Valve House and combined with wastewater effluent from the AWWT Facility. The combined stream flows through the 24-inch force main to the Effluent Aeration Facility.

Ancillary Process Systems

The ancillary process systems that would support the three 2100 gpm groundwater treatment modules include resin regeneration and uranium precipitation, waste processing and disposal, and chemical supply. The following subsections provide a description of these ancillary process systems:

- Resin Regeneration and Uranium Precipitation: Exhausted resin would be regenerated by recirculating sulfuric acid through the ion exchange vessels. The uranium that is recovered from the resin would be precipitated from the sulfuric acid with caustic soda, concentrated in a thickener and the resulting waste slurry sent to the AWWT Slurry Dewatering Facility for dewatering. A vendor-supplied solidification system (cementation, for example) may be required to stabilize the dewatered waste.

- Waste Processing and Disposal: Spent carbon from the carbon adsorbers and spent resin from the ion exchange vessels would be sluiced, separately, to an agitated spent media tank. Excess sluice water would be decanted from the spent media and pumped back to the equalization tanks for recycling through the system. The spent media slurry would be transferred to a vendor-supplied solidification system (cementation, for example) for waste stabilization. Recovered uranium and other solids recovered from the filtration system would be dewatered at the AWWT Slurry Dewatering Facility and sent to a vendor-supplied stabilization system, if necessary. Stabilized waste would be containerized in drums for on-property or off-site disposal.

- Chemical Supply: The bulk sulfuric acid and caustic soda solutions used by the groundwater treatment process would be received by truck and stored in industry standard tanks located in containment dikes. All necessary precautions as listed in the Material

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Safety Data Sheets would be followed for the systems designs and while handling these chemicals.

L.10.5.2 Effluent Aeration Facility

The Effluent Aeration Facility, provided under Removal Action #3, adds dissolved oxygen to the groundwater/wastewater effluent prior to discharging to the Great Miami River to meet NPDES permit minimum requirements of five ppm of dissolved oxygen.

The Effluent Aeration Facility consists of a 60,000 gallon stainless steel aeration tank and a 900 square foot building that houses two 30 horsepower (hp) water recycle pumps and two 75 hp compressed air blowers. There is additional building space to double the system size, if required.

Treated groundwater, combined with treated wastewater from the AWWT Facility is discharged from the SWRB Valve House to the Effluent Aeration Facility via a 24-inch diameter force main. The groundwater/wastewater is diverted through a 24-inch diameter main to two parallel 20-inch aeration tank inlet lines. Groundwater/wastewater is aerated using four eddy mix jet aerators and discharged from the aeration tank through a 24-inch main to the 24-inch diameter force main. One recycle pump and one air blower operate continuously, and a backup up for each component is available.

Downstream of the Effluent Aeration Facility, the treated groundwater/wastewater is combined at Manhole 176B with non-contaminated wastewater and treated Sewage Treatment Plant effluent from Manhole 175. These combined flows will pass through a parshall flume and outfall monitoring station for FEMP discharge flow measurement and monitoring.

L.10.5.3 South Plume Interim Treatment System

The South Plume Interim Treatment (SPIT) system was installed to provide interim treatment of 200 gpm of South Plume groundwater. The system is housed in a building, which is located just north and adjacent to the SWRB Valve House. The system consists of filtration for particulate removal and ion exchange for uranium removal. The SPIT filtration system consists of a multi-media filter followed by a bag filter. The system uses three ion exchangers in series (two operating, one standby).

South Plume groundwater is tapped from the South Plume 20-inch force main in the SWRB Valve House and pumped to the multi-media filter. The multi-media filter removes particles $\geq$ 5 microns with a 90 percent removal efficiency. Groundwater then flows through the polishing bag filter for removal of particles using 3 microns nominal size bags. Groundwater then flows through the ion exchange vessels. The vessels are loaded with Dowex 21K™ resin to reduce the uranium

concentrations to less than 5 ppb. The treated groundwater is then discharged to the Great Miami River via the SWRB Valve House and the Effluent Aeration Facility. The spent ion exchange resin is not regenerated, but is stored for future regeneration at the AWWT Facility. Multi-media filter backwash is pumped to the General Sump via a 6-inch force main.

L.10.5.4 Plant 8 VOC Treatment System

The existing Plant 8 VOC Treatment System provides removal of organics from contaminated perched groundwater to less than 5 ppb. The system receives water by piping and by tanker unloading into a 6000-gallon collection tank. From the collection tank, the water is pumped at 10 - 12 gpm through bag filters (10-micron), followed by a cartridge filter (3-micron) for particulate removal. Following the filters, the water flows through a series of activated carbon drums for VOC removal. The treated water then flows to a holding tank and is subsequently pumped to the Plant 8 Sump.

L.10.5.5 Storm Water Retention Basin

The Storm Water Retention Basin (SWRB), located south of the former production area, receives storm water runoff from the former production area and from the FEMP parking lots. The SWRB has a retention capacity of about 10 million gallons. The basin consists of an east chamber and a west chamber, which allows collection of water in one chamber while water is discharged from the other chamber. Valving at the SWRB chamber inlets and at the SWRB discharge pumping station accommodates this operation. The basin consists of a primary bottom bentonite lining and an upper high-density polyethylene (HDPE) flexible membrane liner. An underdrain system underneath the HDPE liner is used to monitor and collect leakage through the HDPE liner. The SWRB pump station has a discharge capacity of 700 gpm with a second spare pump provided.

L.10.5.6 SWRB Valve House

The SWRB Valve House is located just north of the SWRB west chamber. The Valve House contains extensive valving to allow diversion of wastewater flows from the SWRB and the South Plume Recovery System to the various interim and future permanent treatment facilities. Valving is also included to divert discharges from the AWWT Facility and future groundwater treatment facilities to the Effluent Aeration Facility and subsequently to the Great Miami River. The valving also allows emergency discharge from the SWRB directly to the Great Miami River to prevent overflow of the SWRB due to extremely heavy rainfall or other operational difficulties. (Overflow of the SWRB is suspected to be a major source of the South Plume contamination.) Flow monitoring and sampling equipment are also provided in the Valve House.

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This facility would remain in service throughout the life of site wastewater treatment and groundwater remediation. Effluent discharges from the AWWT Facility and from proposed groundwater treatment facilities, which constitute the total of treated contaminated groundwater/wastewater from the site, would be routed to the Valve House for diversion to the Effluent Aeration Facility and subsequently to the Great Miami River.

L.10.5.7 Interim Advanced Wastewater Treatment Unit at SWRB, IAWWT(SWRB)

The IAWWT(SWRB) is also located just north of the SWRB east chamber. SWRB discharge is treated by the IAWWT(SWRB) unit prior to discharge to the Great Miami River. The IAWWT(SWRB) unit consists of two trailer-mounted treatment systems, each with a 150 gpm treatment capacity. Prior to entering these two trailer systems, the SWRB discharge is first pumped through multi-media filters, installed in the SPIT Facility, for suspended solids removal. Each trailer system has two feed pumps, two bag filters, two cartridge filters, and three ion exchange columns (loaded with DOWEX 21K™ resin). A dilute sulfuric acid tank and feed system for pH adjustment, a feed tank, and associated pumps are located in a building separate from the trailers.

The IAWWT(SWRB) system is designed to remove uranium to effluent concentrations of less than 5 ppb (less than one ppb performance has been achieved). The treated storm water is discharged through the SWRB Valve House and FEMP outfall line to the Great Miami River. Spent ion exchange resin is not regenerated, but stored for future regeneration at the AWWT Facility. Backwash from the multi-media filters is routed to the General Sump for subsequent treatment.

L.10.5.8 Plant 8 Sump

Plant 8 is located in the western portion of the former production area. The Plant 8 Sump provides radionuclide and heavy metals removal by pH adjustment, chemical precipitation, and filtration. The system has an average treatment capacity of 100 gpm.

Liquid process waste streams from the FEMP site are currently fed directly or via the General Sump to a series of "feed" tanks for storage, pH adjustment, and coagulation/precipitation. From these tanks, wastewaters and/or waste slurries are fed to rotary drum vacuum filters for uranium removal and the filtrate is either sent back to the General Sump, if the uranium concentration is less than 0.0004 lb/gal uranium (48 ppm), or is reprocessed. The filters are precoated with a filter-aid media and the resulting filter cake is placed in 55-gallon drums for storage or disposal.

The filtration equipment is arranged in two process trains. One train consists of two 5000-gallon feed tanks that feed two six-foot diameter by eight-foot long, Eimco rotary drum vacuum filters (East and West Eimcos). This filtrate is sent to a 25,000-gallon tank. A second train consists of five

5000-gallon and one 8000-gallon feed tanks that feed one 8-foot diameter by 10-foot long Eimco rotary drum vacuum filter (Large Eimco). This filtrate is sent to three 6000-gallon filtrate tanks. The feed and filtrate tanks can be valved in alignment with any of the three Eimco filters.

The processing capacity, per eight-hour shift, of the two filter trains is approximately 25,000 gallons of dilute wastewater and 6000 gallons of slurry for the East or West Eimco, and 40,000 gallons of dilute wastewater and 10,000 gallons of slurry for the Large Eimco.

L.10.5.9 General Sump

The General Sump is just northeast of Plant 8. The General Sump is a tank farm (13 tanks with 5000 -50,000 gallons capacity) that is primarily a transfer facility but also has the capability to provide limited treatment consisting of neutralization, precipitation, pH adjustment, and decantation for large quantities of wastewater. The General Sump receives both contaminated and non-contaminated wastewater streams for treatment and/or diversion to Plant 8, the BDN Surge Lagoon or High Nitrate Tank (HNT), or for discharge to the Great Miami River.

Recent improvements have extended the life of the General Sump and improved operating systems. The General Sump will remain in service to provide flow equalization capacity and can be phased out of service as site areas are remediated and wastewater flows diminish.

L.10.5.10 Biodenitrification Surge Lagoon

The Biodenitrification (BDN) Surge Lagoon is located in the southeast area of the Waste Pit Area. It is an eight million-gallon, man-made lagoon that receives contaminated FEMP wastewater from the General Sump as well as controlled storm water runoff from the Clearwell, Waste Pit Area Perimeter, and Pit 6. The discharge from the lagoon is pumped to the BDN Facility. Due to the large volume of the lagoon, a change in the composition of the wastewater entering the lagoon produces relatively constant characteristics for the BDN Facility influent.

The lagoon has a triple liner system with two upper, HDPE membrane liners and a double leachate collection system. The bottom of the lagoon is lined with a 12-inch thick layer of bentonite. Wastewater is pumped from the Surge Lagoon to the BDN Facility from a pump station located at the southeast corner of the BSL. Two submersible 200 gpm pumps are installed.

L.10.5.11 High Nitrate Tank

The High Nitrate Tank (HNT) is located southeast of the Biodenitrification Surge Lagoon (BSL). The HNT is a 500,000 gallon tank used for storing high nitrate-concentration (more than 2000 mg/l) wastewater from the General Sump. Concrete secondary containment surrounds the HNT. HNT

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wastewaters are combined with BSL discharge and transferred to the BDN by means of two 60 gpm pumps.

Control of BDN Facility influent nitrate concentration is maintained by use of the BSL and HNT. The General Sump effluent is transferred to either the HNT or BSL depending upon its nitrate concentration. HNT contents are metered into the BDN influent stream by means of a control valve to maintain a relatively uniform nitrate concentration.

L.10.5.12 Biodenitrification Facility

The Biodenitrification (BDN) Facility is located in the western area of the former production area, northwest of Plant 8. The BDN facility was designed for the purpose of reducing nitrates in wastewater. This facility consists of a premix tank, feed tanks, bioreactors, and effluent tank located inside Building 18D. The bioreactors are vertical carbon steel columns four feet in diameter by 52 feet high. Inside the bioreactors are fluidized beds of anthracite coal particles. Each bioreactor is equipped with reactor charge pumps which push the wastewater into the bottom and through to the top, where it overflows into a header. The process is continuous and is capable of treating up to 200 gpm. A minimum of 150 gpm is required through each bioreactor for adequate bed fluidization. Recycle operation is implemented to maintain 150 gpm bioreactor flow at lower net flow rates.

The BDN Facility uses a biological process in which bacteria break down nitrates into nitrogen, carbon dioxide, and water. The biological treatment takes place inside the bioreactors through bacteria which grow on the coal particles. The bacteria are in an anoxic environment and must reduce nitrates for respiration. Methanol is added to the wastewater as a carbon source and phosphoric acid is added as a nutrient source for the bacteria. Because hydroxyl ions are produced in the reaction, the pH of the wastewater increases as treatment proceeds. A pH control system injects sulfuric acid at several points in the flow path to maintain a pH of 6.5 to 8.5 that is conducive to the process. With influent concentrations of 1000 to 1500 mg/l NO_3 (as N), the resulting effluent is less than 30 mg/l NO_3 (as N).

The treated wastewater flows to the effluent tank where final pH adjustment occurs. Effluent pumps are used to transfer wastewater from the effluent tank to the BDN-Effluent Treatment System (BDN-ETS) or recycle tank.

L.10.5.13 BDN Effluent Treatment System

The BDN-ETS) facility is located south of the BDN Facility. The BDN-ETS provides final treatment of the BDN wastewater before it is discharged. The BDN-ETS is basically a standard activated

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sludge treatment system. Its primary function is to reduce the total suspended solids (TSS) and biochemical oxygen demand (BOD) levels in the effluent from the BDN Facility.

The main components of the BDN-ETS are an aeration tank, a clarifier, a sludge thickener, and a disinfection system. The system receives treated wastewater from the BDN Facility at a rate which ranges from 50 to 200 gpm in normal operation. The system is designed to produce discharge levels of 30/45 mg/l BOD_5 (daily average/daily maximum) and 30/45 mg/l TSS (daily average/daily maximum).

L.10.5.14 Interim Advanced Wastewater Treatment Unit at BDN-ETS, IAWWT(BDN-ETS)
The IAWWT(BDN-ETS) unit is located at the BDN-ETS facility. The IAWWT(BDN-ETS) is designed to treat a maximum of 100 gpm of water from the BDN-ETS to reduce the uranium concentration to less than 5 ppb using ion exchange.

Wastewater flows from the BDN-ETS clarifiers to the hold tank located in the BDN-ETS Building (18H). From the hold tank, the water is pumped through multi-media filters and bag filters to remove solids. The filtered water is treated in ion exchange vessels to remove uranium. Spent resin is not regenerated, but stored for future regeneration at the AWWT Facility. The treated water is pumped to the BDN-ETS chlorine contact and effluent tank, and then discharged to the Great Miami River.

L.10.5.15 Advanced Wastewater Treatment Facility
The AWWT Facility is located in Building 51 in the southwest corner of the former production area. The AWWT Facility is scheduled to be operational in early 1995 for final treatment of all site contaminated storm water and other wastewater. The facility will have a total treatment capacity of 1100 gpm - 700 gpm for storm water (Phase I) and 400 gpm for other wastewater (Phase II). It will also provide perched groundwater treatment and will supplement interim South Plume groundwater treatment. The AWWT Facility is expected to remain in operation until 2019.

Figure L.10-7 illustrates a simplified AWWT process flow diagram. Both phases of the AWWT Facility use the following process operations:

- Flow equalization and pH adjustment with caustic in preparation for the downstream coagulation process.
- Coagulation with alum or potassium ferrate followed by clarification for reduction of suspended solids, uranium and other radionuclides, and heavy metals. Other coagulant chemicals may be trialed, after start-up, as part of process optimization efforts.

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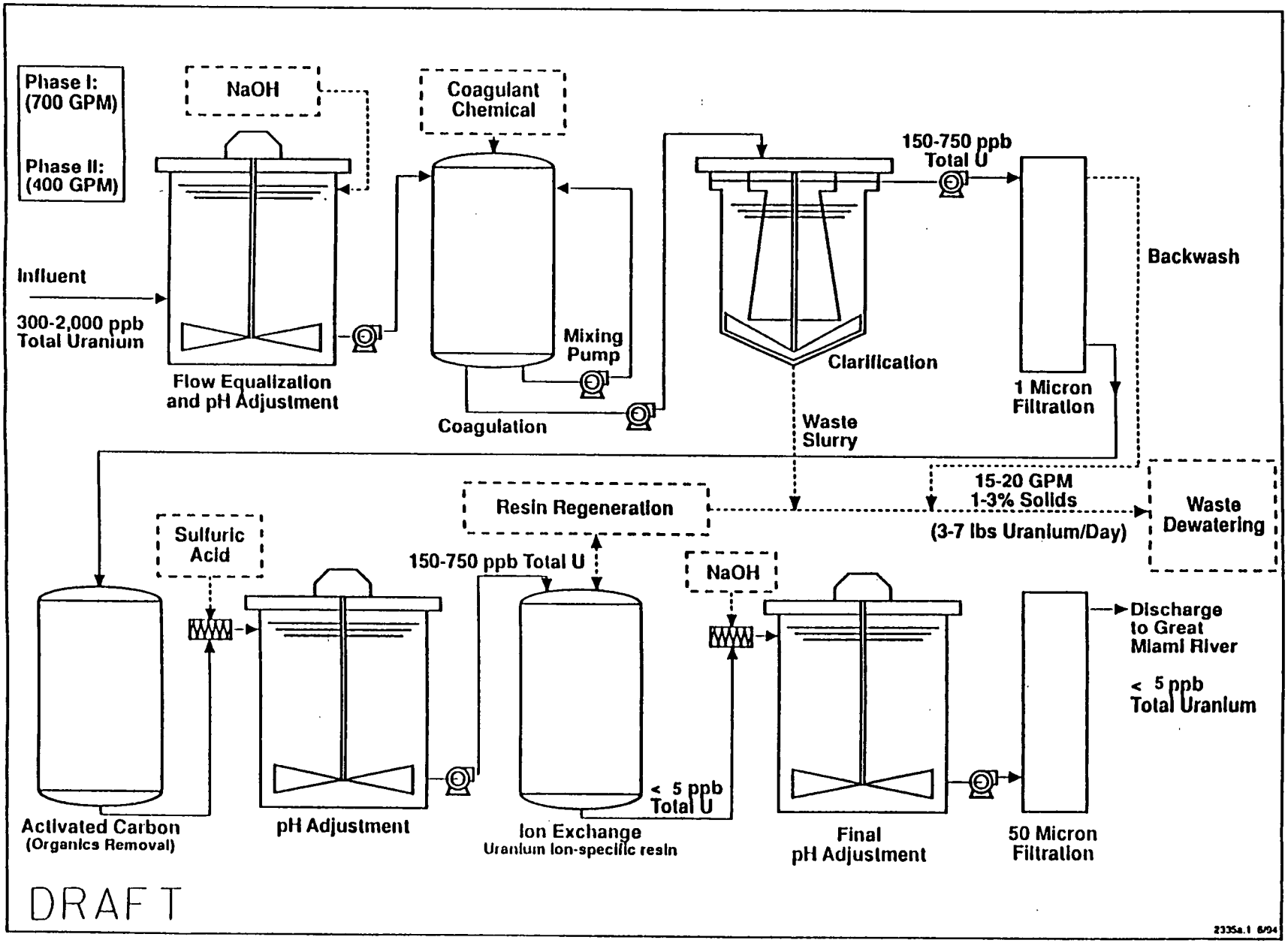

FIGURE L.10-7. ADVANCED WASTEWATER TREATMENT PLANT (PHASES I & II) SIMPLIFIED PROCESS FLOW DIAGRAM

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- Filtration using multi-tube filters to remove suspended solids from the clarifier overflow. The filters would be cleaned by backwashing.

- Adsorption with activated carbon for organic contaminant removal.

- pH adjustment to 8 and ion exchange as follows:

- Three ion exchange resin vessels, three regeneration tanks, and two pumps (one standby) are in the 400 gpm system. The wastewater would flow through two ion exchange resin vessels in lead/lag series with the third vessel available for regeneration.

- 700 gpm of storm water/groundwater would be split into two 350 gpm streams, each flowing through two ion exchange vessels in lead/lag series with the other two vessels available for regeneration.

- Ion exchange resin regeneration will be done by circulating dilute sulfuric acid through the ion exchange vessels. The resulting eluate undergoes precipitation, then thickening. The resulting waste slurry is combined with clarifier bottoms and filter backwash.

- Final pH adjustment, filtration, and discharge: Both the 400 gpm and 700 gpm treated streams are combined in the pH mixing/recycle tank, filtered using multi-tube filters, and discharged to the SWRB Valve House for subsequent discharge to the Great Miami River.

- Eluate treatment and waste slurry pumping to Plant 8: Eluate is mixed with 20 percent NaOH, heated, and pumped through two precipitators in series. The slurry is pumped from the second precipitator through an in-line mixer to the inclined plate thickener. Dilute caustic is added in the two precipitators and also at the in-line mixer. Thickener underflow, as well as clarifier underflow and filter backwashes, is pumped to the waste slurry surge tank. The waste slurry collected in the surge tank is pumped to Plant 8 for further treatment. Treatment in Plant 8 will be discontinued when the new AWWT Slurry Dewatering Facility becomes operational in late 1995. Thickener overflow is pumped to the recycle tank, then to the equalization tank.

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L.10.5.16 AWWT Slurry Dewatering Facility

The AWWT Slurry Dewatering Facility is scheduled to be operational in late 1995 and will be located at the AWWT Facility. The primary purpose of the new AWWT Slurry Dewatering Facility is the processing (dewatering) of waste slurries and sludges from the AWWT Facilities and those generated from future groundwater remediation treatment. The dewatering of miscellaneous site waste sludges (i.e., those from the SWRB, BDN Surge Lagoon, Sewage Treatment Plant, etc.) may also be performed at this new facility.

The total estimated volume of slurry that would be fed to the slurry dewatering facility includes 25,000 gallons per day from the AWWT Facility, 3500 gallons per day from groundwater remediation treatment, and undefined volumes from other miscellaneous sources. Therefore, the AWWT Slurry Dewatering Facility will have an estimated treatment capacity of about 30,000 gallons per day. The AWWT and groundwater treatment waste slurries are estimated to contain between one and three percent solids.

The proposed AWWT Slurry Dewatering Facility consists of three primary operational steps: thickening and clarification, filtration, and drying. The dewatered waste material will be packaged for on-property or off-site disposal. A flow diagram of the system is illustrated in Figure L.10-8.

L.10.5.17 Non-Contaminated Wastewater Treatment

As described above, non-contaminated wastewater is routed to the General Sump for subsequent discharge to Manhole 175. In the near future, these streams will be rerouted for direct discharge to Manhole 175, and the former non-contaminated side of the General Sump will be used for contaminated streams.

Sanitary sewage waste is currently treated at the FEMP Sewage Treatment Plant, which is located southeast of the former production area. The Sewage Treatment Plant consists of a sewage lift station, primary settling basins, trickling filters, secondary settling basins, an anaerobic digester, and ultraviolet disinfection units.

L.10.5.18 Groundwater/Wastewater Discharge to the Great Miami River

The proposed disposition of treated FEMP groundwater/wastewater is described below:

The effluent from the AWWT Facility and from groundwater treatment facilities will be discharged to the SWRB Valve House. From the Valve House, these combined streams flow to the Effluent Aeration Facility to adjust the dissolved oxygen concentration. At Manhole 176B, downstream of the Effluent Aeration Facility, non-contaminated wastewater from Manhole 175 is combined with the

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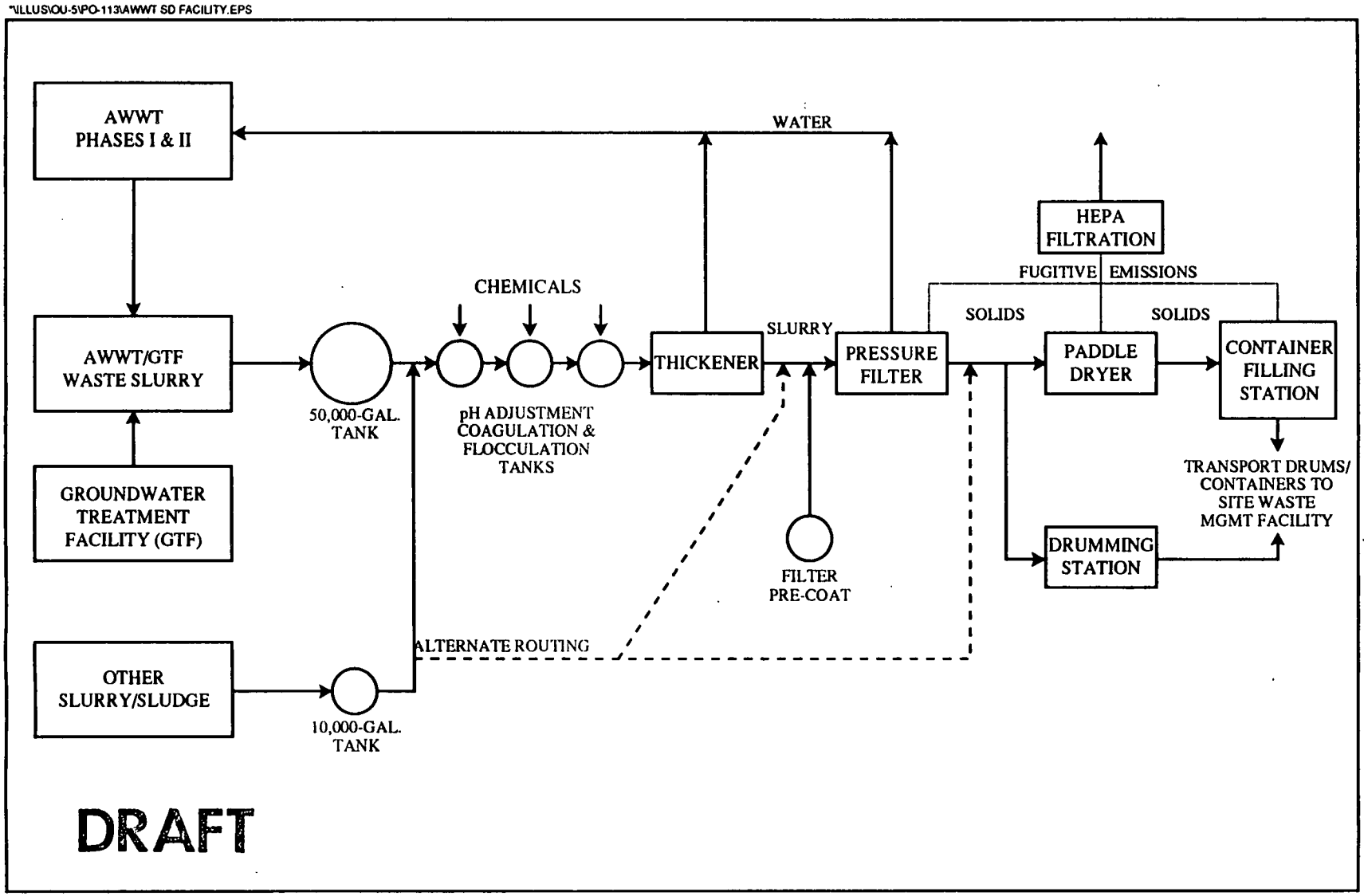

FIGURE L.10-8. FLOW DIAGRAM OF AWWT SLURRY DEWATERING FACILITY

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effluent from the Aeration Facility. This total FEMP wastewater discharge flows through a parshall flume for flow measurement. At this outfall monitoring point, sampling will also be performed to obtain analysis for NPDES and other required outfall reporting. From the parshall flume, the total discharge flows through the outfall piping to the Great Miami River.

L.11.0 CENTRAL STORAGE FACILITY

According to the Removal Action 17 Work Plan, approximately 7100 yd^3 of contaminated soil are currently stored on site in controlled stockpiles while awaiting final disposition. It is anticipated that an additional 1100 yd^3 of contaminated soil would be generated before 1998 as a result of ongoing or future remedial actions, construction projects, and removal actions.

The Removal Action 17 Work Plan proposes construction of a Central Storage Facility (CSF) to provide interim storage of current contaminated soil stockpiles. The CSF would be a containment structure that would store contaminated soil and non-recoverable debris generated from various areas throughout the FEMP. The CSF is intended to store contaminated soil containing a total uranium activity concentration greater than 100 pCi/g, a total radium concentration exceeding 5 pCi/g, a total thorium concentration exceeding 50 pCi/g, or nonradiological regulated waste materials. Materials would be segregated in the containment structure based on the type of contamination (i.e., asbestos, petroleum, PCB, hazardous, radioactive, and mixed). The currently designed CSF storage capacity is as follows:

- 5000 yd^3 for bulk soil
- 4970 ft^2 for bulk hazardous debris
- 4970 ft^2 for containerized hazardous material/debris

Material would remain in the CSF until it can be decontaminated, treated, or packaged for final disposal pursuant to the selected remedial alternative. Material from the CSF would not be used as backfill.

The CSF would be an unheated tension support structure on a concrete pad with secondary containment. The CSF would have forced ventilation equipment to remove vehicle fumes from inside the facility. The CSF would have a sump drain system to collect water which may leach from stored soils and debris or result from vehicle washing and decontamination.

After the existing soil stockpiles are remediated, the CSF would be retained for use as a staging facility for small quantities (less than or equal to 50,000 yd^3) of contaminated materials which exceed the waste acceptance criteria for on-site disposal and, therefore, must be shipped offsite for disposal.

APPENDIX M

SCREENING AND EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS

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LIST OF ACRONYMS

ARAR	applicable or relevant and appropriate requirement
AWWT	advanced waste water treatment (facility)
BNL	Brookhaven National Laboratory
Btu	British thermal unit
CBC	circulating bed combuster
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CSF	central storage facility
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
FEMP	Fernald Environmental Management Project
FS	feasibility study
GRA	general response action
HEPA	high efficiency particulate air (filter)
HWMU	hazardous waste management unit
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NORM	naturally occurring radioactive material
NPDES	National Pollution Discharge Elimination System
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
O&M	operations and maintenance
OEPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
ppb	parts per billion
PPE	personal protection equipment
ppm	parts per million
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
SWIFT	Sandia Waste Isolation Flow and Transport (model)
UV	ultraviolet
VOC	volatile organic compound

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M.1.0 OVERVIEW

Section 3.0 of this feasibility study (FS) summarizes the results of the identification, screening and evaluation of applicable technologies and process options that will be used to assemble the remedial action alternatives for Operable Unit 5. The intent of Appendix M is to provide a more complete description of the universe of process options considered, and to show the rationale involved in the initial screening and evaluation procedures as applied to each of the process options considered in this report.

Remedial action alternatives for Operable Unit 5 were developed by identifying remedial technologies and process options within these technologies that may be applied to the various contaminated media at the site. These media include groundwater, which encompasses both the Great Miami Aquifer groundwater and perched groundwater, and soil, which includes on- and off-property soil and sediment. The identification, screening and evaluation of technologies and process options have been conducted in consideration of these two major media types.

Technologies considered in selecting remedial action alternatives for these media include those identified in 40 CFR 300, relevant U.S. Environmental Protection Agency (EPA) RI/FS guidance, (EPA 1988a), the Operable Unit 5 Initial Screening of Alternatives Report, and FS's for other FEMP operable units. Additional technologies were considered based on experience and information gained through remedial action planning and implementation at similar sites.

Media-specific remedial technologies and associated process options were identified for each of the general response actions. Each process option was initially screened for technical implementability; i.e., information such as site conditions and types and concentrations of contaminants were used to eliminate or screen out various process options that would either not apply or could not be technically implementable at the site. If no viable process option remained from a technology family, the technology was also eliminated. This initial screening process reduces the variety of possible process options within a given technology group to a smaller, more manageable number of options which can then be subjected to evaluation.

The purpose of evaluation is to obtain a reasonable number of process options to combine into remedial alternatives. The evaluation step only compares similar process options within a specific remedial technology group. At the conclusion of the evaluation, a representative process option(s) will be selected from those remaining in each technology group. This is done to minimize the generation of large numbers of similar alternatives. Selecting a representative process option does not preclude the use of other acceptable process options in the remedial design.

M.2.0 INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

The identification and initial screening of technologies and process options applicable to groundwater are presented in Table M.2-1. This table summarizes the general response actions, remedial technologies, and process options associated with the Great Miami Aquifer and perched groundwater media and presents the results of the initial screening process. Unshaded areas in this table represent those technologies/process options which have passed initial screening procedures. Technologies and process options to address collected storm water and process wastewaters generated during remedial actions are included, where appropriate, in the following discussions addressing groundwater due to the similarity in contaminants of concern (COCs). In addition, the technologies and process options applicable to nonrecoverable debris and the residual streams resulting from the treatment of the Great Miami Aquifer, perched groundwater, collected storm water, and process wastewaters will be addressed in the discussions within the soil and sediment sections of this appendix.

Following is a description of the identification and initial screening for the universe of technologies and process options which were considered to be potentially applicable to groundwater media within Operable Unit 5. Table M.2-2 presents the technologies and process options for groundwater, process wastewater and storm water that have passed the initial screening process, and will be retained for further evaluation.

M.2.1 NO ACTION

The no-action general response action is retained as a baseline for comparison to other remedial alternatives, as required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The no-action response provides no additional remediation, maintenance, or security activities at the site to further minimize risk to public health and the environment.

M.2.2 INSTITUTIONAL CONTROLS

Institutional controls are used to restrict intentional or unintentional use or contact with contaminated groundwater. Institutional controls are typically segmented into active and passive controls. Active controls would include monitoring technologies to examine contaminant migration, while passive controls would include legal measures such as deed restrictions.

M.2.2.1 Monitoring Technologies

Monitoring would be conducted during the implementation of any selected remedial action alternative to assess short-term impacts to workers and the public. Additionally, sampling and/or monitoring would be employed following completion of remedial actions to demonstrate attainment of remedial

TABLE M.2-1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
(Unshaded items indicate passing initial screening process)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No activities conducted at site to address contamination.	Required by NCP
Institutional Controls	Monitoring	Groundwater Monitoring	Sampling of newly installed or existing wells to assess contaminant migration in groundwater.	Potentially applicable to GMA and perched groundwater
		Leachate Monitoring	Sampling and analysis of leachate collection systems.	Potentially applicable to perched groundwater
		Surface Water Monitoring	Sampling and analysis of storm water runoff or treated groundwater discharged to surface streams.	Potentially applicable to GMA and perched groundwater.
	Access/Use Restrictions	Alternate Water Supply	Replacement of contaminated groundwater source with alternative water supply for end user.	Potentially applicable to GMA.
		Physical Barriers	Barrier used to restrict site access (e.g., fencing, security, etc.)	Potentially applicable to GMA and perched groundwater.
		Deed Restrictions	Administrative action using property deeds to restrict future site activities.	Potentially applicable to GMA and perched groundwater.
		Continued Federal Ownership	Continued property ownership of all or part of the FEMP site to restrict future site activities through ownership rights.	Potentially applicable to GMA and perched groundwater.
Containment	Capping	Single Layer Cap	Low-permeability cap over an area of contamination; low permeability materials include concrete, asphalt, soil, clay, synthetic membrane, etc.	Not applicable. Does not meet the design life criteria.
		Multilayer Cap	Cap formed with multiple layers including topsoil, clay, synthetic membrane, sand/gravel, etc.	Potentially applicable to GMA and perched groundwater.
	Subsurface Water Control	Vertical Slurry Wall	Vertical slurry barrier used to restrict lateral migration of groundwater and isolate contaminants.	Potentially applicable to perched groundwater
		Horizontal Slurry Barrier	Horizontal slurry barrier used to restrict vertical migration of contaminated groundwater.	Potentially applicable to perched groundwater
		Grout Curtain	Use of pressure-injected cement to restrict lateral migration of groundwater; typically used in porous or fractured bedrock.	Not applicable. No confining geologic layer available to key into.

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TABLE M.2-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment (continued)	Subsurface Water Control (continued)	Subsurface Drains	Gravity flow French drain type collection system used to contain shallow groundwater.	Potentially applicable to perched groundwater
		Sheet Piling	Sheet piling joined and driven into ground to prevent horizontal migration of contaminated groundwater.	Potentially applicable to perched groundwater
		Pumping Wells	Injection or extraction wells used to contain and/or redirect contaminated groundwater flow by altering hydraulic gradient.	Potentially applicable to GMA and perched groundwater.
Removal	Subsurface Water Extraction	Vertical Extraction Wells	Discrete conventional pumping wells used to remove contaminated groundwater.	Potentially applicable to GMA and perched groundwater.
		Directional Extraction Wells	Discrete pumping wells, directionally drilled at an angle, used to remove contaminated groundwater.	Potentially applicable to GMA and perched groundwater.
		Wellpoint System	Numerous closely spaced extraction wells which use a common header and suction pumps to remove shallow contaminated groundwater.	Not applicable. Applied to shallow groundwater; GMA and most perched groundwater zones are too deep.
		Collection Trench/French Drain	A permeable trench used to collect, convey or divert surface water, groundwater or leachate flow.	Potentially applicable to perched groundwater
		Excavation	Use of conventional earthmoving equipment and pumping to access and remove contaminated groundwater during contaminated soil excavation.	Potentially applicable to perched groundwater
		Electroosmosis	Application of an electrical field to induce groundwater flow through soil.	Potentially applicable to perched groundwater
		Bedrock Fracturing	Blasting or hydrofracturing of bedrock to promote access to contaminated groundwater located in bedrock formations.	Not applicable. Amount of contaminated groundwater in bedrock formations insignificant.
Treatment	In Situ	Chemically Induced Soil Flushing	Inject chemicals into the soil to enhance the contaminants solubility and mobility in the groundwater.	Not applicable. Varied subsurface conditions would result in channeling and poor contact times.
		Vapor Sparging	Injecting air or CO_2 into the groundwater to increase the solubility and mobility of contaminants.	Potentially applicable to GMA and perched groundwater.
		Bioremediation	Enhancement of biodegradation of organic contaminants by the addition of oxygen, microorganisms, and/or nutrients to the groundwater.	Not applicable. Majority of contaminants are not amenable to biodegradation.

TABLE M.2-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Physical	Equalization	Dampening of flow and/or contaminant concentration variation in a large basin or tank to promote constant discharge rate and water quality before further processing.	Potentially applicable to GMA and perched groundwater.
		Sedimentation/ Clarification	Gravity settling of suspended solids from water in a basin or clarifier.	Potentially applicable to GMA and perched groundwater.
		Ultrafiltration	Removal of dissolved high molecular weight contaminants and fine suspended or colloidal particles from water by forcing the contaminated liquid through filter membranes.	Potentially applicable to GMA and perched groundwater.
		Multimedia Filtration	Separation of suspended matter from water via flow through a bed of sand, anthracite, etc.	Potentially applicable to GMA and perched groundwater.
		Flotation	Separation of oils and suspended matter less dense than water via gravity separation, or dissolved or indirect air flotation.	Not applicable. Free oil and fine suspended particulates are not major concerns.
		Reverse Osmosis	Use of high pressure and membranes to separate dissolved materials, including organics and inorganics from water.	Potentially applicable to GMA and perched groundwater.
		Volatilization	Contact of water with gas stream to remove volatile compounds; air stripping or steam stripping methods are typically employed.	Potentially applicable to GMA and perched groundwater.
		Adsorption	Adsorption of contaminants onto a substrate media such as activated carbon, resins or activated alumina.	Potentially applicable to GMA and perched groundwater.
		Evaporation	Change water from liquid to gaseous state at temperature to separate suspended and dissolved contaminants.	Not applicable. Not feasible for low contaminant levels.
		Distillation	Heat used to separate organic contaminants from water based on the difference in boiling points.	Not applicable due to low organic concentrations.
		Crystallization	Refrigeration used to separate contaminants from water based on the difference in freezing points.	Not applicable. Not feasible for low contaminant levels.
	Chemical	Ion Exchange	Process in which noncontaminant ions, held by electrostatic forces to charged functional groups on the ion exchange resin surface, are exchanged for contaminant ions of similar charge in a water stream.	Potentially applicable to GMA and perched groundwater.

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TABLE M.2-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Chemical (continued)	Solvent Extraction (Liquid/Liquid)	Separation of contaminants from water by contact with an immiscible solvent with a higher affinity for the contaminants of concern.	Not applicable due to low organic concentrations.
		Electrodialysis Reversal	Recovery of anions or cations using special membranes under the influence of an electrical current.	Potentially applicable to GMA and perched groundwater.
		Electrolytic Recovery	Passage of an electric current through water with resultant ion recovery on positive and negative electrodes.	Not applicable. Not feasible for low contaminant levels.
		Coagulation/ Flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Potentially applicable to GMA and perched groundwater.
		Polymerization	Chemical catalysts used to promote the combining of monomers to form long chained polymers removable by filtration or settling.	Not applicable. No organic monomer contaminants present in groundwater.
		Dehalogenation	Use of chemicals to remove halogen atoms from organic compounds in water.	Not applicable due to low organic concentrations.
		Neutralization (pH Adjustment)	Use of acids or bases to neutralize high or low pHs or to adjust pH to satisfy the requirements of a given process.	Potentially applicable to GMA and perched groundwater.
		Chemical Precipitation	Use of reagents to convert soluble contaminants into insoluble state to be removed by filtration or settling.	Potentially applicable to GMA and perched groundwater.
		Hydrolysis	Lime or caustic used to decompose organic contaminants in a reaction which generates water.	Not applicable due to low organic concentrations.
		Enhanced Oxidation	Use of strong oxidizers such as ultraviolet light, ozone, peroxide, chlorine, or permanganate to chemically oxidize materials; typically hydrogen peroxide (and/or ozone) with UV light is used for groundwater remediation.	Potentially applicable to GMA and perched groundwater.
		Chemical Reduction	Use of strong reducing reagents such as sulfur dioxide, sulfite, or ferrous iron to chemically reduce the oxidation state of contaminants, thus making them more amenable to removal from a liquid stream.	Potentially applicable to GMA and perched groundwater.
	Physical/ Chemical	Treatment by Advanced Waste Water Treatement (AWWT) Facility	Treatment of perched groundwater, storm water and process wastewater by AWWT system using equalization, pH adjustment, chemical precipitation, clarification, filtration, carbon adsorption and ion exchange.	Potentially applicable to perched groundwater

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TABLE M.2-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Thermal	Wet Air Oxidation	Treatment of groundwater with air at high temperature and pressure to enhance oxidation of organic contaminants.	Not applicable due to low organic concentrations.
	Biological	Aerobic Detoxification	Suspended growth or fixed film process employing aeration and biomass recycle to decompose organic contaminants.	Not applicable due to low organic concentrations.
		Aerobic/ Anaerobic Detoxification	Suspended growth facultative process in pond or basin employing long detention times and aerobic/ anaerobic biomass to decompose organic contaminants.	Not applicable due to low organic concentrations.
		Anaerobic Detoxification	Suspended growth or fixed film process employing anaerobic biomass to decompose organic contaminants.	Not applicable due to low organic concentrations.
		Biosorption	Use of an algae-based ion exchange resin to remove heavy metals and radionuclides from groundwater	Potentially applicable to GMA and perched groundwater.
		Denitrification	Use of bacteria to reduce nitrates and nitrites to molecular nitrogen.	Not applicable. Nitrogen compounds are not of concern.
Disposal/ Discharge	On-Property	Beneficial Reuse	Reuse of treated groundwater, as necessary, for site process water.	Potentially applicable to GMA and perched groundwater.
		Direct Discharge to Surface Water	Discharge of treated groundwater to Paddys Run.	Potentially applicable to GMA and perched groundwater.
	On-Property/ Off-Property	Surface / Subsurface Discharge	Use of reinjection wells or spray irrigation to discharge treated groundwater to underground.	Potentially applicable to GMA.
	Off-Property	Indirect Discharge to POTW	Discharge of untreated water to a publicly owned treatment works (POTW).	Not applicable. Volume of removed groundwater is too great.
		Indirect Discharge to Permitted Facility	Discharge of untreated water to a permitted commercial treatment facility.	Not applicable. Volume of removed groundwater is too great.
		Direct Discharge to Surface Water	Discharge of treated groundwater to the Great Miami River	Potentially applicable to GMA and perched groundwater.

TABLE M.2-2

GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS RETAINED FOR FURTHER EVALUATION

General Response Action Components	Technology	Process Option
No Action	None	Not applicable (G,P)
Institutional Controls	Monitoring	Groundwater monitoring (G,P) Leachate monitoring (P) Surface water monitoring (G,P)
	Access/Use Restrictions	Alternate water supply (G) Physical barriers (G,P) Deed restrictions (G,P) Continued Federal ownership (G,P)
Containment	Capping	Multilayer cap (G,P)
	Subsurface Water Control	Vertical slurry wall (P) Horizontal slurry barrier (P) Subsurface drains (P) Sheet piling (P) Pumping wells (G)
Removal	Subsurface Water Extraction	Vertical extraction wells (G,P) Directional extraction wells (G,P) Collection trench/French drain (P) Excavation (P) Electroosmosis (P)
Treatment	In Situ	Vapor sparging (G,P)
	Physical	Equalization (G,P) Sedimentation/clarification (G,P) Ultrafiltration (G,P) Multimedia filtration (G,P) Reverse osmosis (G,P) Volatilization (G,P) Adsorption (G,P)
	Chemical	Ion Exchange (G,P) Electrodialysis reversal (G,P) Coagulation/flocculation (G,P) Neutralization (pH adjustment) (G,P) Chemical precipitation (G,P) Enhanced oxidation (G,P) Chemical reduction (G,P)
	Physical/Chemical	Treatment by AWWT facility (P)
	Biological	Biosorption (G,P)
Disposal/Discharge	On-Property	Beneficial reuse (G,P) Direct discharge to Paddys Run (G,P)
	On-Property/Off-Property	Surface/subsurface discharge (G)
	Off-Property	Discharge to Great Miami River (G,P)

(G) Potentially Applicable to Great Miami Aquifer Groundwater
(P) Potentially Applicable to Perched Groundwater

action objectives and, as necessary, assess the continued performance of wastewater treatment and disposal systems and groundwater management systems. Monitoring process options include:

- Groundwater monitoring
- Leachate monitoring
- Surface water monitoring.

Groundwater Monitoring Process Option

This process option involves the sampling and analysis of groundwater using existing and/or new monitoring wells to evaluate plume management remediation techniques by evaluating contaminant migration in both the Great Miami Aquifer and affected perched water zones. Groundwater monitoring is applicable to both Great Miami Aquifer groundwater and perched groundwater and has been retained for further evaluation.

Leachate Monitoring Process Option

For this process option, leachate from contaminated soil would be monitored using existing and/or newly constructed monitoring wells, seepage basins, or diversion ditches. Leachate monitoring is applicable to perched groundwater and has been retained for evaluation.

Surface Water Monitoring Process Option

Monitoring of surface water is useful in definition and management of groundwater contamination sources. In addition, monitoring of discharges of recovered and/or treated groundwater and process-generated wastewater to receiving streams is required under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Compliance monitoring is conducted at the Fernald Environmental Management Project (FEMP) at all discharge points to a receiving stream. Such monitoring is envisioned to continue for all discharges from the site to local surface streams. Surface water monitoring is applicable to any treated Great Miami Aquifer groundwater or perched groundwater and has been retained for further evaluation.

M.2.2.2 Access/Use Restrictions

Access/use restrictions would be implemented to regulate access to the site or development of the site to preclude human exposure to contaminated media. This technology category includes active controls, which consist of physical barriers such as fences, gates, and security forces, and passive controls, which include administrative actions such as continued ownership and deed restrictions. Access/use restrictions include:

- Alternate water supply
- Physical barriers

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- Deed restrictions
- Continued federal ownership.

Alternate Water Supply

This process option would involve the replacement of a contaminated groundwater source with an alternative potable water supply for the end user. Under the terms of the South Groundwater Contamination Plume Removal Action, an alternate groundwater supply system was provided to one industrial user. A small ion exchange system, supplied by the FEMP, is being substituted for contaminated groundwater at one residence located to the south of the FEMP, and bottled water is presently being supplied to a number of local residences in the South Plume area. The treatment system and bottled water are considered interim measures until final plans are formulated and implemented for Operable Unit 5 through the CERCLA process. Additionally, the FEMP is cooperating with Hamilton County, Ohio, in the installation of a public water supply system to areas adversely impacted by the contaminated groundwater. This public water supply system will permit the discontinuance of the use of the small ion exchange treatment system and the bottled water. Each of the FEMP remedial alternatives takes into consideration the use of this alternate water supply system as a near-term measure to eliminate contaminated groundwater usage. The use of a permanent alternative water supply is applicable to Great Miami Aquifer groundwater only and has been retained for evaluation.

Physical Barriers

Physical barriers limit the potential for inadvertent public or worker exposure to on-property contamination by restricting entry. Public access to the FEMP production area is controlled by security forces, fencing, and signs. Use of this process option would include continuing the use of such barriers to restrict access and human contact with portions or all of the FEMP property to minimize the potential for exposure to site contaminants. No consideration is being given to extending physical barriers off FEMP property to potentially impacted adjacent areas, except as necessary to preclude human intrusion into active remediation areas. This process option is applicable to both Great Miami Aquifer and perched groundwater at the site and has been retained for further evaluation.

Deed Restrictions

Deed restrictions involve restricting the use of land during and after remediation by recording the restrictions in property deeds. Deed restrictions could be employed to restrict groundwater usage from on and off FEMP property areas during and after active remediation. Deed restrictions are applicable to both Great Miami Aquifer and perched groundwater and have been retained for evaluation.

Continued Federal Ownership

Continued federal ownership involves continued control of portions or all of the FEMP property by the federal government with the intent to restrict site development activities through the rights oft ownership. Under this process option, on-property development activities such as agricultural or residential usage could be restricted or eliminated by the federal government, which as the property owner, would retain all rights to preclude these activities. The federal government would continue custodial oversight of the property through the Department of Energy (DOE) or another governmental agency. No consideration is being given in this FS to extending such rights of ownership off the FEMP property through purchase of potentially affected neighboring properties. This process option is applicable to both Great Miami Aquifer and perched groundwater at the site and has been retained for further evaluation.

M.2.3 CONTAINMENT

Long-term containment consists of technologies that confine contaminated media to their current locations. These technologies limit the migration of contaminants from affected media and reduce the associated potential for exposure. While such response actions reduce the potential for contaminant transport by precluding transporting media (i.e., rainwater, wind, etc.,) from contacting impacted media, the technologies do not affect the actual toxicity, mobility or volume of the contaminated media. Containment actions include capping and subsurface water control technologies.

M.2.3.1 Capping Technologies

A contaminated area can be capped by placing low-permeability physical barriers to restrict infiltration of precipitation to contaminated soil, sludge, or sediment that could result in contaminant leaching. A stabilized surface fill would be required before cap placement. Design life of any cap should be 1000 years, which is the general applicable or relevant and appropriate requirement (ARAR)-based requirement for caps being considered for wastes of the type present in Operable Unit 5. Capping process options include:

- Single-layer cap
- Multilayer cap.

Single-Layer Cap Process Option

A single-layer cap uses concrete, asphalt, synthetic membranes, or soil to effectively control erosion and minimize precipitation infiltration. All of these single-layer caps are subject to weathering; however, the periodic application of special surface treatment chemicals will help maintain the integrity and low permeability of the concrete and asphalt caps. Because the design life for single-layer caps is significantly less than 1000 years, this process option will be eliminated from further consideration.

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Multilayer Cap Process Option

The multilayer cap combines the most effective attributes of single-layer capping options by using more than one barrier material to form multiple layers over the contaminated media. These caps typically consist of vegetative cover, topsoil, sand/gravel, clay, and impermeable synthetic membrane layers. This layered design offers the highest degree of effectiveness by using the properties of the various layers to control erosion and limit infiltration while providing weather protection. Multilayer capping can meet the 1000 year life requirement, is applicable to perched groundwater and the Great Miami Aquifer, and has been retained for evaluation.

M.2.3.2 Subsurface Water Control Technologies

Subsurface contamination can be isolated by lateral barriers such as slurry walls, subsurface drains, pumping wells, grout curtains, or sheet pilings. The purposes of these technologies are to collect and control leachate flow and to prevent clean Great Miami Aquifer or perched groundwater from contacting contaminated subsurface soil. The effectiveness of subsurface flow controls depends upon the size and depth of the affected area and the nature of site-specific geologic and hydrogeologic conditions. Subsurface water control technologies include:

- Vertical slurry walls
- Horizontal slurry barrier
- Grout curtains
- Subsurface drains
- Sheet piling
- Pumping wells.

Vertical Slurry Wall Process Option

A vertical slurry wall is used to restrict lateral flow of groundwater and thus isolate subsurface soil contamination. A slurry wall is a fixed underground physical barrier that is formed by pumping a slurry (usually a soil, cement, bentonite, and/or water mixture) into a trench as excavation proceeds, allowing the slurry to set while backfilling. The slurry is used primarily to maintain the trench during excavation. Due to depth limitations for vertical slurry walls, this process option would only be applicable to perched groundwater and has been retained for additional evaluation to be used as a support option in conjunction with other containment options.

Horizontal Slurry Barrier Process Option

A horizontal slurry barrier is used to restrict vertical flow of groundwater and thus isolate subsurface soil contamination. Horizontal barriers are formed by pumping a slurry made up of a soil, cement and/or bentonite, and water mixture into notched injection holes enabling the formation of a barrier beneath an area of contamination. This horizontal barrier, used in conjunction with vertical slurry walls and a top cover, can effectively isolate an area of contaminated groundwater. Due to the depth

limitations for this process option, it would only be applicable to perched groundwater for use as a support technology in conjunction with other containment options.

Grout Curtain Process Option

A grout curtain is a narrow, vertical wall installed into the ground to divert laterally flowing groundwater. This underground barrier is formed by injecting either a particulate grout such as portland cement or a chemical grout such as sodium silicate into the ground. This type of barrier is typically applied to seal porous or fractured bedrock. This process option is only effective to depths of approximately 30 to 40 feet and requires a confining layer of clay or rock into which the bottom of the grout curtain is keyed. Grout curtains will be eliminated from further consideration as a containment process option because there is no confining layer shallow enough to key into at the FEMP site.

Subsurface Drains Process Option

Subsurface drains include any type of buried conduit used to collect, convey, or divert groundwater or leachate by gravity flow. A subsurface drainage system often includes perforated drain pipe or a gravel bed to convey flow to a storage tank or sump for further processing. Due to the depth limitations of subsurface drains, this process option would only be applicable to perched groundwater and has been retained for additional evaluation.

Sheet Piling Process Option

Sheet pilings are constructed by driving webbed sections of sheet piling into the ground. Sections are joined before being driven into the ground and initially are not watertight. However, the joints eventually fill with fine-to-medium-grained soil particles which usually block the major flow of water, but are generally not watertight. Because of unpredictable wall integrity, sheet pilings are seldom used except for the temporary dewatering of construction sites or as erosion protection where another barrier intersects flowing water. Sheet piling will be considered for further evaluation as a support option to be used during perched water excavation activities.

Pumping Wells Process Option

Pumping wells either extract or inject water in order to contain or remove a groundwater contamination plume or adjust groundwater levels to prevent plume migration. Pumping wells can also be used in conjunction with other groundwater containment controls to maximize system efficiency. This process option could be applicable to the Great Miami Aquifer groundwater at the FEMP site and has been retained for further evaluation.

M.2.4 REMOVAL

The removal general response action applies to groundwater at the FEMP site before eventual treatment and/or discharge. Subsurface water extraction is the only remedial technology applicable for the removal of contaminated groundwater.

M.2.4.1 Subsurface Water Extraction Technologies

Removal of groundwater can be performed by vertical and directional extraction wells, wellpoint systems, collection trenches, excavation, electroosmosis, and bedrock fracturing. These process options do not reduce contaminant mobility, toxicity, or volume, but they are required in order to remove and convey contaminated groundwater to ex situ treatment. The subsurface water extraction process options include:

- Vertical extraction wells
- Directional extraction wells
- Wellpoint system
- Collection trench/French drain
- Excavation
- Electroosmosis
- Bedrock fracturing.

Vertical Extraction Wells Process Option

Vertical extraction wells are used to capture contaminated groundwater in overburden deposits and bedrock. They could be used in conjunction with ex situ groundwater treatment technologies to remediate contaminated groundwater. As discussed in the previous section, vertical extraction wells can also be used to either extract or inject water in order to contain or reduce a groundwater contamination plume, or adjust groundwater gradient levels to prevent plume migration. This process option would be applicable to both Great Miami Aquifer and perched groundwater at the FEMP site and has been retained for further evaluation.

Directional Extraction Wells Process Option

Directional extraction wells use the same principles as vertical extraction wells except they are directionally drilled at an angle rather than vertically drilled into a groundwater zone. The advantage is that directional wells can pump water from a larger subsurface cross section and thus reduce the number of wells required. At the FEMP site, this process option would be applicable to both perched and Great Miami Aquifer groundwater and has been retained for additional evaluation.

Wellpoint System Process Option

A wellpoint system consists of numerous closely spaced wells which are connected to a common header and pumped from a single location by a suction pump. This can be a cost-effective process

option for removing shallow groundwater; however, the maximum depth limitation of approximately 22 feet for this technology would not be sufficient for extracting Great Miami Aquifer and most perched groundwater at the FEMP site. Therefore, wellpoint systems will be eliminated from consideration as a viable removal process option.

Collection Trench/French Drain Process Option

A collection trench or French drain includes any type of excavated trench or buried conduit used to collect, convey, or divert groundwater or leachate by gravity flow. This process option often uses perforated drain pipe or a gravel bed to convey flow to a storage tank or sump for further treatment and/or disposal. Due to depth limitations of about 40 feet, a collection trench or French drain would not be applicable to Great Miami Aquifer groundwater at the FEMP site, but it has been retained for further evaluation as a removal process option for perched groundwater.

Excavation Process Option

Excavation involves the use of common construction equipment such as a backhoe or other standard equipment to remove soil or sediment. This process option, used in conjunction with dewatering techniques, would be applicable at the FEMP site to remove shallow pockets of contaminated perched groundwater within zones of contaminated soil which are also to be remediated by excavation. This process option has been retained for the removal of perched groundwater and will be further evaluated.

Electroosmosis Process Option

Electroosmosis is a technique used for the dewatering of soil that contains significant concentrations of ionized inorganic contaminants. In this process an electrical field is applied to the soil to induce groundwater flow in a certain direction. Due to the large areas of soil contamination associated with the site, this technology would not be applicable to the Great Miami Aquifer groundwater; however, it could apply to the smaller perched groundwater zones and will be retained for more detailed evaluation.

Bedrock Fracturing Process Option

Bedrock fracturing involves the blasting or hydrofracturing of bedrock to promote access to contaminated groundwater contained within bedrock formations. This process option would not apply to either the perched groundwater zones, which are made up of glacial overburden, or to the Great Miami Aquifer, which is basically a sand and gravel aquifer. Therefore, bedrock fracturing will be eliminated from consideration as a process option for the removal of groundwater.

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M.2.5 TREATMENT

The treatment general response action includes the following treatment technology types: in situ, physical, chemical, physical/chemical, thermal, and biological. Treatment is used to reduce the toxicity, mobility, and/or volume of a contaminated material.

M.2.5.1 In Situ Treatment Technologies

In situ treatment technologies such as chemical flushing and vapor sparging could be considered indirect treatment techniques which increase the solubility and mobility of contaminants in the groundwater, thereby reducing the total remediation time required when used in conjunction with various removal and ex situ treatment technologies. Other process options such as in situ bioremediation can be used to directly treat groundwater contaminated with biodegradable organics. In situ treatment process options include:

- Chemically induced soil flushing
- Vapor sparging
- Bioremediation.

Chemically Induced Soil Flushing Process Option

In situ soil flushing is a process applied to unexcavated soil and used in conjunction with a removal technology such as a groundwater extraction/reinjection system. This process option consists of injecting a solvent or surfactant solution to enhance contaminant solubility in the groundwater and thus increase contaminant recovery. Soil flushing could be applicable as a way to speed up the contaminant removal process. However, due to the very large areas of contaminated soil and the heterogeneous nature of the subsurface environment, channeling and poor contact times will reduce the effectiveness of this process option. Chemically induced soil flushing will therefore be eliminated from consideration as an in situ treatment process option.

Vapor Sparging Process Option

Vapor sparging is an in situ process that forces a gaseous medium into the groundwater in conjunction with a removal technology such as a groundwater extraction/reinjection system or a vapor extraction system. This process option could be applied to the Great Miami Aquifer as a technique used to increase the solubility/mobility of contaminants, particularly uranium, which would be oxidized to the hexavalent state, preferably in the carbonate form. The optimum sparging gas for the purpose of converting uranium into the highly mobile carbonate form would be carbon dioxide. Sparging with air could also increase the mobility of uranium in a carbonate-rich soil and groundwater matrix. Sparging with air or carbon dioxide has been retained for further evaluation as a process option to increase the mobility of contaminants in the Great Miami Aquifer in order to effectively reduce the time period for aquifer restoration.

Bioremediation Process Option

Bioremediation is an in situ process that uses bacteria to biodegrade various organic contaminants by injecting oxygen and nutrients, such as nitrogen and phosphorus, into the groundwater and associated soil. Microorganisms, usually those indigenous to the soil, are used to completely degrade organic compounds into water and carbon dioxide in the presence of oxygen and nutrients, near neutral Ph, and ambient soil temperatures. Because the great majority of the COCs are radionuclides, heavy metals, and refractory (nonbiodegradable) organics, this process option is not considered applicable for remediating Operable Unit 5 groundwater. Therefore, bioremediation will be eliminated from consideration as an in situ treatment process option.

M.2.5.2 Physical Treatment Technologies

Physical treatment technologies could be applied to remove contaminants from recovered groundwater, collected storm water, and process wastewater. Physical treatment facilities are currently operational at the FEMP addressing collected storm water flows and process wastewater. These technologies contain both support and primary treatment process options. Equalization and the separation processes such as sedimentation/clarification, ultrafiltration, multimedia filtration, and flotation would be considered minor or support treatment process options. Reverse osmosis, volatilization, adsorption, evaporation, distillation, crystallization, and ion exchange would be considered major or primary treatment process options. Physical treatment process options include:

- Equalization
- Sedimentation/clarification
- Ultrafiltration
- Multimedia filtration
- Flotation
- Reverse osmosis
- Volatilization
- Adsorption
- Evaporation
- Distillation
- Crystallization.

Equalization Process Option

Equalization is a treatment support option which involves the dampening of variations in flow rate and/or contaminant concentration by detaining wastewater flows in large tanks or basins. Equalization prevents flow and/or contaminant concentration surges that could adversely upset subsequent (i.e., downflow) treatment operations. Equalization is presently employed at the FEMP as part of site wastewater treatment systems. Equalization could be applicable to the treatment of both the Great Miami Aquifer and perched groundwater, as well as storm water and process

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wastewater flows in Operable Unit 5, and has been retained for evaluation as a physical treatment process option.

Sedimentation/Clarification Process Option

This process option consists of the gravity settling of suspended solids from water in a clarifier (clarification) or large basin (sedimentation). This process could be applicable as a treatment support option for all Operable Unit 5 groundwater, storm water, and process wastewater, and has been retained for further evaluation.

Ultrafiltration Process Option

Ultrafiltration is a low-pressure membrane filtration process that separates high molecular weight solutes or colloids from an aqueous solution. Ultrafiltration could be applicable for the removal of fine suspended or colloidal particles, or any high molecular weight organic contaminants which might be found in Operable Unit 5 groundwater, process wastewater, and collected storm water. This physical treatment support option has been retained for further evaluation.

Multimedia Filtration Process Option

Multimedia filtration is a process where water flows through porous multimedia, such as anthracite and sand, to remove suspended solids. This process is effective in removing both organic and inorganic contaminants that are bound to suspended solids in the water stream. This process option could be applicable to all water media in Operable Unit 5 as a pretreatment step to the primary treatment processes, or it could be applicable as a final polishing step following the primary treatment processes. Multimedia filtration has been retained for further evaluation as a physical treatment support option to reduce suspended solids in all Operable Unit 5 groundwater, process wastewater and collected storm water.

Flotation Process Option

Flotation involves the separation of oils (or other fine particles less dense than water) from water using a gravity separator or a gas bubbling mechanism such as a dissolved or induced air flotation system. Because free oil phases and fine suspended particulates are not major COCs in Operable Unit 5 groundwater, flotation will be eliminated from consideration as a treatment process option.

Reverse Osmosis Process Option

Reverse osmosis uses high pressure and a semipermeable barrier that will pass only certain components of a solution. The membrane is permeable to water, but impermeable to most dissolved organic and inorganic substances. Clean water is produced on the downflow side of the membrane while a concentrated reject stream, containing organic and inorganic contaminants, remains on the upflow side. Reverse osmosis could be applicable in treating most dissolved contaminants in both

Great Miami Aquifer and perched groundwater, and therefore has been retained for additional evaluation.

Volatilization Process Option

Volatilization, or air stripping, involves the passing of large volumes of air through water contaminated with volatile organic compounds (VOCs) in a packed column, or involves the use of diffused aeration to promote the transfer of the volatile contaminants to the air stream. Steam stripping is a similar process except that steam is used as the carrier gas and provides heat to enhance removal. Volatilization could be applicable to the treatment of low level VOCs in both Great Miami Aquifer and perched groundwater and has been retained for further evaluation.

Adsorption Process Option

Adsorption involves the physical attraction of solute molecules to exchange sites on the internal pore surface areas of various media such as activated carbon, activated alumina, or resins. Activated carbon is most widely used in the treatment of water and wastewater for the removal of a wide range of organic contaminants, and could be applicable to Great Miami Aquifer and perched groundwater and other collected storm water and process wastewater as a means of removing organics. It has been retained as a physical treatment process option for further evaluation.

Evaporation Process Option

Evaporation is the conversion of water from a liquid to a gaseous state at a high temperature as a means of removing suspended and dissolved solids from the water being treated. As a treatment option, evaporation is normally applied to slurries and water streams with higher solids and contaminant concentrations than those found in the Great Miami Aquifer and perched groundwater in Operable Unit 5. Therefore, this process will be eliminated from further consideration as a physical treatment option.

Distillation Process Option

In the distillation process, heat is used to separate various organic contaminants from water based on the difference in boiling points. The process is most often used to separate or purify organic product streams, some of which could contain aqueous fractions, and is rarely used for groundwater or surface water remediation. Due to relatively low organic concentrations in Operable Unit 5 groundwater, distillation will be eliminated from consideration as a physical treatment process option.

Crystallization Process Option

Freeze crystallization uses refrigeration to separate contaminants from water, based on the differences in freezing points. For this process to be effective, contaminant concentrations would have to be

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considerably higher than those currently present in the groundwaters in Operable Unit 5. Therefore, crystallization will be eliminated from consideration as a process option.

M.2.5.3 Chemical Treatment Technologies

Chemical treatment technologies include support and primary treatment process options which could be applied to recovered Operable Unit 5 groundwater, collected storm water, and process wastewater. Coagulation/flocculation and neutralization would be considered support options, while solvent extraction, electrodialysis, electrolytic recovery, polymerization, dehalogenation, chemical precipitation, hydrolysis, reduction, and enhanced oxidation would be considered primary treatment process options. Chemical precipitation was employed at the FEMP for over 40 years as the primary treatment process for addressing uranium production processing wastewater. A chemical precipitation treatment process is currently under construction as part of the advanced wastewater treatment (AWWT) facility, as discussed in M.2.5.4.

Chemical treatment process options include:

- Ion exchange
- Solvent extraction
- Electrodialysis reversal
- Electrolytic recovery
- Coagulation/flocculation
- Polymerization
- Dehalogenation
- Neutralization
- Chemical precipitation
- Hydrolysis
- Enhanced oxidation
- Chemical reduction.

Ion Exchange Process Option

Ion exchange is a process in which noncontaminant ions, held by electrostatic forces to charged functional groups on the ion exchange resin surface, are exchanged for contaminant ions of similar charge in the water stream. Ion exchange is currently being effectively used at the FEMP site to treat low-level uranium-bearing wastewater. Ion exchange could be applied to all recovered groundwater, collected storm water and process wastewater as a treatment process option for the removal of inorganic contaminants, including heavy metals and radionuclides. Therefore, the ion exchange process option has been retained for further evaluation.

Solvent Extraction (Liquid/Liquid) Process Option

Solvent extraction is a process in which a liquid solvent, immiscible in water and with a higher affinity for the organic contaminants than water, is used to separate those contaminants from the water

medium. The contaminants can then be recovered from the solvent through evaporation or distillation techniques. This process option is not applicable to the Operable Unit 5 groundwater, storm water, or process wastewater since organic contaminant concentrations are not sufficiently high to make solvent extraction effective. Therefore, it will be eliminated from consideration as a chemical treatment process option.

Electrodialysis Reversal Process Option

Electrodialysis is an electrochemical separation process in which ions are transferred through water-impermeable membranes from a less concentrated to a more concentrated solution by means of direct electric current. Electrodialysis reversal uses electrical polarity reversal, through an arrangement of electrodialysis reversal membrane stacks, to continually produce demineralized water. A membrane stack consists of a set of electrodes with a series of alternating anion and cation transfer membranes. Electrodialysis reversal could be applicable to Great Miami Aquifer and perched groundwater, collected storm water, and process wastewater for the treatment of heavy metals and radionuclide contamination, and has been retained for further evaluation.

Electrolytic Recovery Process Option

Electrolytic recovery involves the recovery of contaminant anions and cations from water onto positive and negative electrodes when an electric current is passed through the water medium. As a treatment option, electrolytic recovery is normally applied to wastewater with higher contaminant concentrations than those found in the Operable Unit 5 groundwater, storm water, and process wastewater. Therefore, electrolytic recovery will be eliminated from further consideration as a chemical treatment process option.

Coagulation/Flocculation Process Option

Coagulation/flocculation are closely related processes that involve the addition of chemical reagents to a wastewater to neutralize the surface charges on finely graded suspended particulates and promote particle agglomeration, thus encouraging the formation of larger particles that are too large to remain in suspension. This process option could be applicable to all Operable Unit 5 recovered groundwater, storm water, and process wastewater as a support step to chemical precipitation in the removal of heavy metals and radionuclides. This process option has been retained for further evaluation.

Polymerization Process Option

Polymerization involves the use of chemical catalysts to promote the formation of long-chained organic polymers from organic monomer contaminants. The heavy, long-chained polymers can then be removed by filtration or settling techniques. Polymerization would not be applicable to the Operable Unit 5 groundwater, storm water, or process wastewater because they do not contain

significant concentrations of organic monomer contaminants. This process option will be eliminated from further evaluation.

Dehalogenation Process Option

Dehalogenation is accomplished by using reducing agents such as sulfur dioxide or sodium sulfite to strip halogen atoms such as chlorine from organic compounds. For this process to be effective, halogenated organics would have to be considerably higher in concentration than are currently present in the groundwater, storm water, or process wastewater in Operable Unit 5. Therefore, dehalogenation will be eliminated from consideration as a chemical treatment process option.

Neutralization (pH Adjustment) Process Option

Neutralization is the adjustment of a water's pH by the addition of an acid or base so that the water is no longer acidic or basic. This process could be used for the treatment of acidic or alkaline water, or as a support process to adjust pH to a certain level in order to maximize the efficiency or requirements of other treatment/disposal options. Neutralization could be applicable as a support treatment process option for Operable Unit 5 wastewater, storm water, and recovered groundwater and has been retained for further evaluation.

Chemical Precipitation Process Option

Chemical precipitation involves the addition of an acid or base, often in conjunction with a coagulant/flocculant aid, to adjust the pH in a wastewater to a point where inorganic contaminants have a lower solubility and thus tend to precipitate out of solution. This process option could be applicable for treating heavy metals and radionuclide contaminants in Operable Unit 5 groundwater, storm water, and process wastewater. Chemical precipitation has been retained for further evaluation as a chemical treatment process option.

Hydrolysis Process Option

Hydrolysis is the process of breaking a bond in an organic molecule that is normally not water soluble so that it will go into solution. Typically a chemical reagent such as an acid or caustic is added to the solution to achieve the desired reaction. However, it can also be achieved by photolysis or through the use of enzymes. Water is generated in the reaction. Hydrolysis would not be applicable to the Operable Unit 5 storm water, process wastewater, and recovered groundwater due to the low organic contaminant concentrations. This treatment option will be eliminated from further consideration.

Enhanced Oxidation Process Option

This process option involves the use of strong oxidizers such as ozone, peroxide, permanganate, or chlorine in conjunction with photolysis to raise the oxidation state of a contaminant and thereby change the solubility, stability, or separability of that contaminant. The process most commonly used

in groundwater remediation is hydrogen peroxide and/or ozone in conjunction with ultraviolet light. Enhanced oxidation could be applicable to Operable Unit 5 groundwater, storm water and process wastewater for the treatment of certain organic and inorganic contaminants and has been retained as a process option for further evaluation.

Chemical Reduction Process Option

Chemical reduction involves the use of strong reducing reagents such as sulfur dioxide, sulfites, or ferrous iron to lower the oxidation state of a contaminant and thereby change its solubility, stability, or separability. This process option could be applicable to Operable Unit 5 groundwater, storm water, and process wastewater for the treatment of certain inorganic contaminants and has been retained as a chemical treatment process option.

M.2.5.4 Physical/Chemical Treatment Technologies

To address the low concentrations of the various organic and inorganic contaminants found in the site's storm water, process wastewater and groundwater, a process which combines many of the identified physical and chemical process options would be required. This process option, as described below, has been designed to achieve compliance with the terms of a DOE order and to support the completion of a supplemental project agreed to by DOE and EPA. The physical/chemical process option evaluated is advanced wastewater treatment.

AWWT Facility Process Option

The AWWT facility, which is currently under construction on the FEMP property, has sufficient design treatment capacity to treat all the projected process wastewater to be generated by remedial actions for Operable Units 1 through 5, collected site storm water, and extracted perched groundwater. The system presently under construction does not have sufficient design capacity to treat the expected flows of extracted groundwater from the Great Miami Aquifer. The AWWT facility consists of the following sequential treatment steps: equalization, pH adjustment (1st stage), chemical precipitation, clarification, filtration, carbon adsorption, pH adjustment (2nd stage), ion exchange, neutralization, and final filtration. Each of the treatment processes contained in the AWWT facility has been previously discussed and has passed initial screening in this FS. On this basis, the AWWT facility is retained for further evaluation, and is applicable to perched groundwater, storm water and process wastewater.

M.2.5.5 Thermal Treatment Technologies

This technology includes only one treatment process option--wet air oxidation.

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Wet Air Oxidation Process Option

Wet air oxidization breaks down oxidizable organic and inorganic contaminants using a high temperature, high pressure, aqueous environment. This process is used primarily in the treatment of sanitary wastewater treatment plant sludge or concentrated organic liquid waste streams. Due to the relatively low contaminant concentrations in the storm water, process wastewater, Great Miami Aquifer and perched groundwater, and the resultant low concentrations of organics expected in the residuals generated by other treatment processes, wet air oxidization would not be a practical treatment option and is eliminated from further consideration.

M.2.5.6 Biological Treatment Technologies

There are several biological processes available for treating contaminated waters. Biological treatment process options use living organisms such as bacteria or fungi to detoxify or immobilize contaminants in water media by converting organic and occasionally inorganic contaminants to nontoxic end products. Biological treatment process options include:

- Aerobic detoxification
- Anaerobic detoxification
- Aerobic/anaerobic detoxification
- Biosorption
- Denitrification.

Aerobic Detoxification Process Option

Aerobic detoxification employs aeration and microorganisms to destroy the organic constituents in groundwater or wastewater through decomposition in a suspended growth or fixed film process. This process option would not be applicable to the Operable Unit 5 groundwater, storm water, or process wastewater because the concentrations of organic contaminants are not sufficiently high to support a viable microorganism (biomass) population. Therefore, aerobic detoxification will be eliminated from consideration as a potential biological treatment process option.

Anaerobic Detoxification Process Option

Anaerobic detoxification employs anaerobic biomass to destroy the organic constituents in a groundwater or wastewater through decomposition in a suspended growth or fixed film process. This process option would also not be applicable to the FEMP groundwater and other wastewater due to low organic concentrations. Therefore, anaerobic detoxification will be eliminated from further consideration as a potential biological treatment process option.

Aerobic/Anaerobic Detoxification Process Option

Aerobic/anaerobic detoxification employs both aerobic and anaerobic biomass in conjunction with long detention times to destroy the organic constituents in groundwater or wastewater through decomposition in a suspended growth facultative process in a pond or basin. Once again, this process option would not be applicable to the FEMP groundwater or other wastewater due to low organic concentrations. Therefore, aerobic/anaerobic detoxification will also be eliminated from consideration as a process option.

Biosorption Process Option

Biosorption uses an algae-based resin consisting of algal cells immobilized in a silica gel polymer to adsorb heavy metal ions from an aqueous solution. The process is based on the natural affinity of algae cell walls for heavy metal ions. This process option could be applicable for the treatment of heavy metals and radionuclides with heavy metal properties in the Great Miami Aquifer and perched groundwater at the site. Biosorption has been retained for further evaluation as a potential biological treatment process option.

Denitrification Process Option

Denitrification involves the use of microorganisms to reduce nitrates and nitrites in groundwater and wastewater to molecular nitrogen. This process employs a respiratory mechanism in which the nitrate/nitrite replaces molecular oxygen in bioassimilation. The FEMP currently has an operational large-scale denitrification facility. This facility is planned to be used to support Removal Action Number 20, Stabilization of Uranyl Nitrate Inventories. Following this action, the existing facility is planned to be taken out of active status due to the low nitrate concentration in existing wastewater flows at the site. Denitrification would not be applicable to any of the Operable Unit 5 groundwater, future generation of process wastewater, or collected storm water due to low nitrate and nitrite concentrations. Therefore, this process option will be eliminated from further consideration.

M.2.6 DISPOSAL/DISCHARGE

Several disposal/discharge technologies may be used following removal and treatment as part of the remedial action. Disposal/discharge technologies include on-property, on-property/off-property, and off-property. A discussion of the process options associated with water disposal/discharge technologies is also presented.

M.2.6.1 On-Property Disposal/Discharge Technologies

On-property disposal/discharge process options include:

- Beneficial reuse
- Direct discharge to Paddys Run.

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Beneficial Reuse

Beneficial reuse involves the reuse of treated site groundwater for site process water. Due to the high expected flow rates of recovered groundwater and the reduced demands at the FEMP, not all of the treated groundwater or other treated waste streams could viably be reused. The volume of the treated groundwater would greatly exceed the volume that could be used for cooling, makeup, and other auxiliary process support streams. Beneficial reuse of a portion of the treated groundwater would be applicable to Great Miami Aquifer and perched groundwater, process wastewater, and storm water. Beneficial reuse has been retained for further evaluation.

Direct Discharge to Paddys Run

Direct discharge of treated or untreated site groundwater or storm water to an on-property surface water such as Paddys Run could be accomplished in conjunction with a surface water monitoring (National Pollution Discharge Elimination System [NPDES] type) program. This process option could not be applied to process wastewater without prior treatment. This process has been retained for evaluation as a potential disposal option.

M.2.6.2 On-Property/Off-Property Disposal/Discharge Technologies

This technology includes only one treatment process option--surface/subsurface discharge.

Surface/Subsurface Discharge

Surface/subsurface discharge involves the use of spray irrigation or injection wells to discharge treated wastewater onto or below the ground surface. This process option could be used in a groundwater gradient control strategy for the Great Miami Aquifer and has been retained for further evaluation as a disposal process option.

M.2.6.3 Off-Property Disposal/Discharge Technologies

Off-property disposal/discharge process options include:

- Indirect discharge to publicly owned treatment works
- Indirect discharge to a permitted treatment, storage, and disposal facility
- Direct discharge to the Great Miami River.

Indirect Discharge to Publicly Owned Treatment Works Process Option

Due to the large anticipated volume of groundwater and process wastewater expected to be generated by the Operable Unit 5 remediation process, indirect discharge to a publicly owned works for treatment would not be applicable because no facility exists in the FEMP area which is designed to address the type and volume of contaminated FEMP wastewater. Therefore, this process option will not be retained for further evaluation.

Indirect Discharge to a Permitted Treatment Storage and Disposal Facility Process Option

Indirect discharge to an off-site permitted treatment, storage, and disposal facility for treatment would not be feasible because hauling of large volumes of untreated water by either truck or rail would be required. Therefore, this process will be eliminated from further consideration.

Direct Discharge to Surface Water Process Option

Direct discharge of treated Operable Unit 5 groundwater and process wastewater to an off-property surface water such as the Great Miami River could be accomplished in conjunction with a surface water monitoring (NPDES type) program. The FEMP recently completed the installation of a high density polyethylene pipeline to carry treated wastewater flows to the Great Miami River. This process has been retained for further evaluation as a disposal option.

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M.3.0 INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL AND SEDIMENT

The identification and initial screening of technologies and process options applicable to soil and sediment are presented in Table M.3-1. This table summarizes the general response actions, remedial technologies, and process options associated with soil and sediment and presents the results of the initial screening process. Unshaded areas in this table represent those technologies/process options which have passed initial screening procedures. Due to the similarity in COCs, technologies and process options to address various treatment process residuals and nonrecoverable debris are included, where appropriate, in the following discussions addressing soil and sediment. Following is a description of the identification and initial screening for the universe of technologies and process options which were considered for soil and sediment within Operable Unit 5. Table M.3-2 presents the technologies and process options for soil and sediment, nonrecoverable debris and treatment process residuals that have passed the initial screening process, and will be retained for further evaluation.

M.3.1 NO ACTION

The no-action general response action is retained as a baseline for comparison to other remedial alternatives, as required by the NCP. The no-action response provides no additional remediation, maintenance, or security activities at the site to further minimize risk to public health and the environment.

M.3.2 INSTITUTIONAL CONTROLS

Institutional controls are used to restrict intentional or unintentional use or contact with contaminated soil, sediment, and groundwater. Institutional controls are typically segmented into active and passive controls. Active controls include physical barriers and monitoring technologies to examine contaminant migration, while passive controls include legal controls such as deed restrictions.

M.3.2.1 Monitoring Technologies

Monitoring would be conducted during the implementation of any selected remedial action alternative to assess short-term impacts to workers and the public. Additionally, sampling and/or monitoring would be employed following completion of remedial actions to demonstrate attainment of remedial action objectives and, as necessary, assess the continued performance of any engineered on-property disposal systems. Monitoring process options include:

- Surface water monitoring
- Groundwater monitoring
- Leachate monitoring.

TABLE M.3-1

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL AND SEDIMENT

(Unshaded items indicate passing initial screening process)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No activities conducted at site to address contamination.	Required by NCP.
Institutional Controls	Monitoring	Surface Water Monitoring	Sampling and analysis of surface water and storm water ditches to assess contamination.	Potentially applicable.
		Groundwater Monitoring	Sampling of newly installed or existing wells to assess contaminant migration.	Potentially applicable.
		Leachate Monitoring	Sampling and analysis of leachate collection systems.	Potentially applicable.
	Access/Use Restrictions	Physical Barriers	Fencing, markers, and/or warning signs to restrict site access.	Potentially applicable.
		Security Guards	Supplement physical barriers by monitoring for breaches and trespassers.	Potentially applicable
		Deed Restrictions	Administrative action using property deeds to restrict future site activities.	Potentially applicable.
		Continued Federal Ownership	Continued property ownership of all or part of the FEMP site to restrict future site activities through ownership rights.	Potentially applicable.
Containment	Capping	Single Layer Cap	Low permeability cap over an area of contamination; low permeability materials include concrete, asphalt, soil, clay, synthetic membrane, etc.)	Not applicable. Insufficient life expectancy.
		Multilayer Cap	Cap formed with multiple layers including topsoil, clay, synthetic membrane, etc.	Potentially applicable.
	Surface Water Control	Diversion/ Collection	Dikes, berms, channels, chutes, and ditches to control run-on, runoff, erosion, and infiltration.	Potentially applicable as a support action.
		Grading	Recontour the land surface to limit run-on, runoff, erosion, and infiltration.	Potentially applicable as a support action.
		Revegetation	Vegetative cover to stabilize soil.	Potentially applicable as a support action.
		Channel Relocation	Relocate on-site stream to expose clean sediment and/or allow covering of contaminated sediment.	Not applicable. On-site streams are dry during the summer and fall.
		Channel Modification	Modify stream to control sediment deposition or resuspension.	Not applicable. On-site streams are dry during the summer and fall.

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TABLE M.3-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Removal	Excavation	Excavation	Removal of soil and sediment using conventional earthmoving equipment.	Potentially applicable.
		Dredging	Mechanical or hydraulic dredging of sediment and soil below the groundwater table.	Not applicable; conventional excavation methods can be used.
		Sorting/ Separation	Visually sort large debris using mechanical excavation equipment. Use gamma or phtoionization detectors in field to identify radiologically and organic contaminated material.	Potentially applicable as a support action during excavation.
Treatment	Biological	In Situ Aerobic Bioremediation	In situ degradation of organics using microorganisms in an aerobic environment. Oxygen and nutrients would be injected into the subsurface to promote biological activity.	Not applicable to metals and radionuclides found in soil at the site.
		In Situ Anaerobic Bioremediation	In situ degradation of organics using microorganisms in an anaerobic environment. Nutrients and other supplements would be injected into the subsurface to promote biological activity.	Not applicable to metals and radionuclides found in soil at the site.
		Plant Harvesting	Plants are seeded in contaminated area to remove contaminants by root and plant uptake.	Not applicable; may introduce contaminants into food chain.
		Soil Aeration	Air is tilled or injected into soil to promote microbial degradation of organics and to strip volatile organics.	Not applicable to metals and radionuclides found in soil at the site.
		Land Farming	Isolation of contaminated media on a containment pad and supplemented with oxygen and nutrients to enhance biological degradation.	Not applicable to metals and radionuclides found in soil at the site.
	Physical	Dewatering / Drying	Gravity or mechanical dewatering of soil, sludges, and residues.	Potentially applicable as a support action.
		Soil Vapor Extraction	System of air injection and extraction wells to promote transfer of volatile organics to the air.	Not applicable to metals and radionuclides found in soil at the site.
	Physical/ Chemical	Soil Washing	Ex situ extraction of contaminants using a leaching agent such as water, acid, solvent, or chelating agents.	Potentially applicable.
		Soil Flushing	In situ flushing of contaminants using injection/extraction well system and a flushing solution.	Not applicable due to insufficient contact time caused by varied subsurface conditions.

TABLE M.3-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Physical/ Chemical (continued)	Dehalogenation	Use of alkaline reagents such as potassium polyethylene glycolate to chemically strip halogen atoms from organics in contaminated soil.	Not applicable to metals and radionuclides found in soil at the site.
		Physical Separation	Ex situ process to minimize waste through volume reduction by physically separating out size fractions of soil or sediment containing minimal contamination.	Potentially applicable.
	Solidification/ Stabilization	Cement-/Pozzolan-Based Solidification	Cement, lime, or other pozzolanic materials are mixed with soil to immobilize contaminants.	Potentially applicable.
		Thermoplastic Solidification	Soil is mixed with asphalt, bitumen, paraffin, or polyethylene and heated to form a stable solid.	Potentially applicable.
		Organic Polymer Stabilization	Soil is mixed with a polymer and catalyst to form a stable solid.	Potentially applicable.
		Vitrification	Contaminated soil is mixed with molten glass to form a stable solid.	Potentially applicable.
		In Situ (Cement-Based) Solidification	Cement, quicklime, or other grouting materials are mixed in situ with soil to immobilize contaminants.	Not applicable due to inadequate mixing caused by varied subsurface conditions.
		In Situ Vitrification	High current electricity passed through area of contamination in situ to melt the material into a glass-like solid matrix.	Not applicable due to large size and associated energy requirements.
	Thermal	Thermal Desorption	Application of heat at relatively low temperature to remove organics from excavated soil by volatilization. Vapor phase is treated by incineration or carbon adsorption.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.
		Rotary Kiln Incineration	Rotary kiln used to destroy organic contaminants by high temperature incineration.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.

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TABLE M.3-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Thermal (continued)	Fluidized Bed Combustion	Destruction of organic contaminants in a vessel containing a bed of hot, inert granular particles into which waste is injected.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.
		Circulating Bed Combustion	Similar to fluidized bed combustion, except air is added to increase turbulence and operating temperatures are lower.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.
		Radio Frequency Heating	Soils is heated in situ using electrodes placed in the ground. Organics are vaporized and collected at the surface for treatment.	Not applicable. Major COCs are not volatile; following treatment in situ for volatile organics, soil would require excavation to treat radionuclides and inorganics.
		Infrared Incineration	Employs an intense flux of near infrared radiation to initiate and sustain pyrolysis of the feed materials and to destroy organics.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.
		Plasma Centrifugal Furnace	Soil is detoxified by the use of heat from a plasma torch to vaporize organic contaminants and immobilize metals and radionuclides in a nonleachable glass-like matrix.	Potentially applicable.
Storage	Intermediate Storage	Central Storage Facility	Short term storage for staging and packaging of contaminated soil and sediment, residuals, and nonrecoverable debris before shipment to appropriate disposal facility.	Potentially applicable.

TABLE M.3-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Disposal	On-Property	Backfilling	Disposal of treated soil by using it as backfill in on-site excavations.	Potentially applicable.
		Engineered Disposal Cell	Disposal of soil and/or residuals in an on-property disposal cell.	Potentially applicable.
		Consolidation	Consolidating slightly contaminated soil at a central location with grading and cover or capping.	Potentially applicable
	Off-Site	Nevada Test Site (NTS)	Disposal of contaminated soil at NTS.	Potentially applicable.
		Permitted Commercial Facility	Disposal of contaminated soil at a permitted commercial facility.	Potentially applicable.
	Waste Transportation	Truck Transport	Use of trucks for transporting waste from areas of contamination to disposal areas on the site or for off-site disposal.	Potentially applicable as a support action.
		Rail Transport	Use of rail transportation to transport waste off site for disposal.	Potentially applicable as a support action.

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TABLE M.3-2

SOIL AND SEDIMENT TECHNOLOGIES AND PROCESS OPTIONS RETAINED FOR FURTHER EVALUATION

General Response Action Component	Technology	Process Option
No Action	None	Not applicable
Institutional Controls	Monitoring	Surface water monitoring Groundwater monitoring Leachate monitoring
	Access/Use Restrictions	Physical barriers Security guards Deed restrictions Continued Federal ownership
Containment	Capping	Multilayer cap
	Surface Water Control	Diversion/collection Grading Revegetation
Removal	Excavation	Excavation Sorting/separation
Treatment	Physical	Dewatering/drying
	Physical/Chemical	Soil washing Physical separation
	Solidification/ Stabilization	Cement-/Pozzolan-based solidification Thermoplastic solidification Organic polymer stabilization Vitrification
	Thermal	Thermal desorption Rotary kiln incineration Fluidized bed combustion Circulating bed combustion Infrared incineration Plasma centrifugal furnace
Storage	Intermediate Storage	Central storage facility
Disposal	On-Property Disposal	Backfilling Engineered disposal cell Consolidation
	Off-Site Disposal	Nevada Test Site Permitted commercial facility
	Waste Transportation	Truck transport Rail transport

Surface Water Monitoring

Monitoring of surface water is useful in assessing contaminant migration, if any occurs, from areas where contaminant concentrations are above acceptable regulatory requirements. Surface water monitoring is applicable to soil and sediment and has been retained for further evaluation.

Groundwater Monitoring

Groundwater monitoring involves the sampling and analysis of groundwater using existing and/or new monitoring wells to evaluate the performance of any engineered disposal or containment systems. Groundwater monitoring has been retained for further evaluation.

Leachate Monitoring

Leachate monitoring involves the sampling and analysis of leachate from contaminated soil using existing and/or newly constructed monitoring wells, seepage basins, and diversion ditches to evaluate the performance of any engineered disposal or containment systems. Leachate monitoring has been retained for further evaluation.

M.3.2.2 Access/Use Restrictions

Access/use restrictions would be implemented to regulate access to the site or development of the site to preclude human exposure to contaminated media. This technology category includes active controls, which consist of physical barriers such as fences, gates, and security forces, and passive controls, which include administrative actions such as continued federal ownership and deed restrictions. Access/use restrictions include:

- Physical barriers
- Security guards
- Deed restrictions
- Continued federal ownership.

Physical Barriers

Physical barriers limit the potential for inadvertent public or worker exposure to on-property contamination by restricting entry. Public access to the FEMP production area is controlled by security forces, fencing, and signs. Use of this process option would include continuing the use of such barriers to restrict access and human contact with portions or all of the FEMP property to minimize the potential for exposure to site contaminants. No consideration is being given in this FS to extending such physical barriers beyond FEMP property to potentially impacted adjacent areas, except as necessary to preclude human intrusion into active remediation areas. This process option is applicable to Operable Unit 5 soil and sediment, and has been retained for further evaluation.

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Security Guards

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

Deed Restrictions

Deed restrictions involve restricting the use of land during and after site remediation by recording the restrictions in property deeds. Deed restrictions could be employed to restrict intrusion into contaminated soil on existing FEMP property areas during and after active remediation. Deed restrictions are applicable to soil and sediment and have been retained for evaluation.

Continued Federal Ownership

Continued federal ownership involves continued ownership of portions or all of the FEMP property by the federal government with the intent to restrict site development activities through the rights of ownership. Under such a process option, on-property development activities such as agricultural or residential use could be restricted or eliminated by the federal government, which, as the property owner, would retain all rights to preclude these activities. The federal government would continue custodial oversight of the property through the DOE or another governmental entity (i.e., Department of the Interior). No consideration is being given in this FS to extending such rights of ownership off the FEMP property through purchase of potentially affected neighboring properties. Continued federal ownership has been retained for further evaluation.

M.3.3 CONTAINMENT

Long-term containment consists of technologies that confine contaminated media to their current locations. These technologies limit the migration of contaminants from affected media and reduce the associated potential for exposure. While such response actions reduce the potential for contaminant transport by precluding transporting media (e.g., rainwater runoff, wind, etc.,) from contacting impacted media, the technologies do not reduce the actual toxicity, mobility or volume of the contaminated media. Containment actions include capping and surface water control technologies.

M.3.3.1 Capping Technologies

Capping involves the installation of a low-permeability barrier over the surface of a contaminated area. Capping is designed to control erosion, prevent the generation of leachate due to surface water infiltration, and control direct and indirect exposure to contaminants through inhalation, ingestion, or dermal contact. Both single-layer and multilayer caps are potentially applicable. Single-layer caps include the use of clay, soil, asphalt, concrete, or synthetic membranes. Special coatings may be needed for asphalt and concrete caps. While installation of a multilayer cap is more complex than the single-layer cap, it may be applicable to areas that require more confinement due to greater associated

health and/or environmental risks. In addition, a multilayer cap may be considered to be an integral part of an on-property landfill or disposal cell. A stabilized surface fill would be required before cap placement. Design life of any cap should be 1000 years, which is the general ARAR-based requirement for caps being considered for wastes of the type present in Operable Unit 5. Capping process options include:

- Single-layer cap
- Multilayer cap.

Single-Layer Cap Process Option

A single-layer cap uses concrete, asphalt, synthetic membrane, soil, or clay to effectively control erosion and minimize precipitation infiltration. All of these single-layer caps are subject to weathering; however, the periodic application of special surface treatment chemicals will help maintain the integrity and low permeability of the concrete and asphalt caps. Single-layer capping is applicable to soil and sediment and has been retained for further evaluation. Since the design life for single-layer caps is significantly less than 1000 years, this process option will be eliminated from further consideration.

Multilayer Cap Process Option

The multilayer cap incorporates the most effective attributes of single-layer options by using more than one barrier material to form multiple layers over the contaminated media. These caps typically consist of vegetative cover, topsoil, sand/gravel, clay, and impermeable synthetic membrane layers. This layered design offers the highest degree of effectiveness by using the properties of the various layers to control erosion and limit infiltration while providing weather protection. Because it can meet the 1000 year life expectancy, multilayer capping is applicable to Operable Unit 5 soil and sediment and has been retained for evaluation.

M.3.3.2 Surface Water Control Technologies

Surface water controls can be used to minimize contamination of surface water by reducing the erosion and transport of contaminated soil. Such controls can also be used to minimize the erosion of caps, disposal cells, and landfill covers. Surface water control process options include:

- Diversion/collection
- Grading
- Revegetation
- Channel relocation
- Channel modification.

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Diversion/Collection Process Option

Diversion/collection of surface water is conducted by constructing dikes, berms, channels, chutes, and ditches. The use of these options prevents clean water from contacting waste material or prevents surface water which has already contacted contaminated material from being released in an uncontrolled manner. These process options are considered to be support actions and will be carried further in the evaluation process.

Grading Process Option

Grading consists of recontouring the land surface to prevent excessive erosion from the flow of runoff and surface water. Regrading is considered to be a support action and will be carried further in the evaluation process.

Revegetation Process Option

Revegetation consists of planting grasses or other similar types of vegetative support to stabilize soil, thus minimizing wind erosion and erosion from surface water runoff. Revegetation is considered to be a support action and will be carried further in the evaluation process.

Channel Relocation Process Option

Channel relocation would be used to relocate a stream to either expose contaminated sediment for excavation or to allow the covering of contaminated sediment with clean materials. Although channel relocation is technically implementable, the sediment in on-site intermittent streams can easily be removed or otherwise remediated during a prolonged dry period that typically occurs between June and December. Therefore, channel relocation is eliminated from further evaluation.

Channel Modification Process Option

Channel modification would be used to alter the hydraulics of a stream to control sediment deposition or resuspension. Although channel modification is technically implementable, the sediment in on-site intermittent streams can easily be removed or otherwise remediated during a prolonged dry period with less disturbance to the surrounding environment. Therefore, channel modification is eliminated from further evaluation.

M.3.4 REMOVAL

Complete or partial removal of contaminated material would eliminate or reduce a source of contamination and, therefore, eliminate or reduce the potential for migration of contaminants to potential receptors. Removal (excavation) can be accomplished using mechanical excavation equipment or sediment dredging equipment.

M.3.4.1 Excavation Technologies

Contaminated soil can be effectively removed by excavation using standard construction methods and equipment. Similarly, contaminated sediment can be removed through dredging techniques. Excavation process options that were evaluated include:

- Excavation
- Dredging
- Sorting/separation.

Excavation Process Option

Mechanical excavation involves the use of common construction equipment, such as a backhoe, to remove the soil or sediment. These methods are potentially viable for soil and sediment that are not in contact with surface water (i.e., during the dry season) or groundwater. Therefore, mechanical excavation is retained for further consideration.

Dredging Process Option

Mechanical or hydraulic dredging of material from streambeds is a common technique for removing sediment and soil in contact with surface water and groundwater. Dredging is generally used for the removal of large volumes of sediment or soil in permanent bodies of water. The on-site streams are dry for much of the year and the relative volume of sediment that exceeds remediation goals is relatively small. Therefore, conventional excavation methods using earthmoving equipment can be used in the dry stream beds. Because groundwater dewatering techniques can be used when soil excavations are required below the perched groundwater table, dredging will be eliminated from further consideration.

Sorting/Separation Process Option

Sorting/separation will be used to separate excavated materials into one of the three following groups: radiologically contaminated material, other contaminated material, or clean soil. Excavated materials will be sorted visually using mechanical excavating equipment to separate large debris or pockets of radiologically contaminated materials. Materials may also be sorted in the field using gamma detectors or photoionization detectors to detect low-level radioactive waste or volatile organics, respectively. Sorting/separation will minimize the total amount of material to be contained, treated, or disposed of and will be a support action for excavation. Sorting/separation will be carried further in the evaluation process.

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M.3.5 TREATMENT

Treatment technologies include biological, physical, physical/chemical, solidification/stabilization, and thermal processes. Treatment is used to reduce the toxicity, mobility, and/or volume of a contaminated material.

M.3.5.1 Biological Treatment Technologies

Biological treatment is a method of using living organisms such as microorganisms or plants to consume the contaminants in the soil. Biological treatment process options that were evaluated include:

- In situ aerobic bioremediation
- In situ anaerobic bioremediation
- Plant harvesting
- Soil aeration
- Land farming.

In Situ Aerobic Bioremediation Process Option

In situ aerobic bioremediaton is conducted under aerobic conditions by injecting oxygen and nutrients into subsurface soil to promote biological degradation of organics. Biological techniques are not applicable to the treatment of metals and radionuclides, which are the key contaminants of concern for soil and sediment at the FEMP. In situ aerobic bioremediation is eliminated from further consideration.

In Situ Anaerobic Bioremediation Process Option

In situ anaerobic bioremediation is conducted in the absence of oxygen. Anaerobic conditions are obtained by injecting an easily degraded substrate into the soil, which is degraded by aerobic bacteria. During the process the bacteria consumes the available oxygen, causing an anaerobic environment. Nutrients are then injected into subsurface soil to promote biological degradation of organics under anaerobic conditions. Biological techniques are not applicable to the treatment of metals and radionuclides, which are the key contaminants of concern for soil and sediment at the FEMP. In situ anaerobic bioremediation is eliminated from further consideration.

Plant Harvesting Process Option

Plant harvesting is conducted by seeding plants within the area of contamination. The contaminants are removed from the soil through plant uptake. This process option is not considered applicable because contaminants could be introduced into the food chain when the harvested plants are consumed by livestock and/or wildlife. Plant harvesting is eliminated from further consideration.

Soil Aeration Process Option

Contaminated soil is aerated either through tilling the soil or by injecting air through shallow wells. The introduction of air into the soil promotes biological activity which results in degradation of organic chemicals. Additionally, volatile organics will be removed from the soil as a result of the increased air flows. This process option is not applicable to the treatment of metals and radionuclides, which are the key contaminants of concern for soil and sediment at the FEMP. Soil aeration is eliminated from further consideration.

Land Farming Process Option

Land farming is conducted by excavating contaminated soil and placing it on a treatment pad. The soil is enhanced by adding nutrients and by tilling the soil to provide air, both of which promote biodegradation of organic contaminants. This process option is not applicable to the treatment of metals and radionuclides, which are the key contaminants of concern for soil and sediment at the FEMP. Land farming is eliminated from further consideration.

M.3.5.2 Physical Treatment Technologies

Physical treatment technologies are applicable when the properties of the contaminants make them amenable to separation or volatilization. Physical treatment process options include:

- Dewatering/drying
- Soil vapor extraction.

Dewatering/Drying Process Option

Dewatering consists of using gravity or mechanical means to remove liquid from a solid matrix. It would be applicable for dewatering of sediment and soil to improve handling characteristics. It is also applicable for removing water from treatment plant sludges and residues. Dewatering is considered to be a support process option and will be carried further in the evaluation process.

Soil Vapor Extraction Process Option

Soil vapor extraction consists of a system of air injection and extraction wells to promote the transfer of volatile organics from in situ soil to the air. Vapor extraction is most effective in highly permeable soil. Because vapor extraction is not applicable for metals and radionuclides, it is eliminated from further consideration.

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M.3.5.3 Physical/Chemical Treatment Technologies

The physical/chemical processes evaluated include:

- Soil washing
- Soil flushing
- Dehalogenation
- Physical separation.

Soil Washing Process Option

Soil washing is an ex situ treatment process that incorporates the separation of chemical contaminants from the soil matrix by a combination of physical and chemical treatments. Soil aggregates are reduced to a single-grain composition by either mechanical- and/or chemical-based operations, allowing for particle separation based on size and/or density characteristics. Selected physicochemical operations can then aid in the extraction of inorganic, organic, and radiological chemical contaminants from the discrete soil particles. Although physical separation operations within the soil washing may remove a size fraction of the soil containing little or no contamination, selected chemicals may need to be included in the overall soil washing process to enhance dissolution kinetics and effectively remove contaminants from individual soil particles. More aggressive conditions (e.g., type of chemicals, chemical concentration, extraction temperature, and reaction time) may be incorporated into the chemical extraction part of the soil washing process to enhance contaminant removal. Soil washing is potentially applicable to soil and sediment at the site and is retained for further consideration.

Soil Flushing Process Option

Soil flushing involves the removal of organic and inorganic contaminants by washing the contaminated soil in situ by means of a flushing solution. The system consists of injecting an aqueous solution into the area of contamination, and then pumping the contaminated elutriate to the surface for removal, recirculation, or on-site treatment and reinjection. The aqueous flushing solutions may include water, acids, bases, complexing and chelating agents, solvents, surfactants, and certain reducing agents. During elutration, sorbed contaminants are mobilized into the solution by means of solubility, formation of an emulsion, or by chemical reaction with the flushing solution. Insufficient contact time between contaminant and flushing agent is likely at the FEMP site due to organic interferences in the soil media and channeling caused by heterogeneous subsurface conditions. Therefore, the effectiveness of soil flushing on a scale similar in size to this site is severely limited. Soil flushing will be eliminated from further consideration.

Dehalogenation Process Option

Potassium polyethylene glycolate dehalogenation is a process used to dehalogenate organics in contaminated organic liquid, sludge, and soil. The dehalogenation solution reacts with the organic

and displaces a halogen molecule. The soil is mixed with the potassium polyethylene reactant in a heated reactor. The reagent and soil are separated and the reagent can be recycled. This process would only be potentially effective for polychlorinated biphenyls (PCBs) and would not treat metals or radionuclides which are the primary contaminants of concern at the FEMP. Dehalogenation is eliminated from further consideration because of the inability to treat contaminants of concern other than PCBs.

Physical Separation

Physical separation operations like those used for decades in solution mining and mineral extraction have been the focal point of most soil washing processes. The operational premise for a physical separation process is to derive waste minimization through a volume reduction process by separating out a size fraction of the soil containing little or no contamination. Physical separation operations in soil washing have included high pressure water, screening, attrition scrubbing, froth flotation, tall column, electromagnetic separation, mechanical separation, hydrogravimetric separation (including hydrocyclones, mineral jigs, and spiral classifiers), and multigravity separation. The innovative aspect to these physical separation-based operations is the unique application of these technologies to specific soil-contaminant matrices. More aggressive conditions (e.g., operating temperature, chemical extractants, attrition scrubbing, etc.), within selected operations of the physical separation process can be incorporated to enhance extraction of contaminants from the surface of soil particles. These conditions may also be enhanced through innovative applications of each operation. Physical separation is potentially applicable to site soil and sediment and is retained for further evaluation.

M.3.5.4 Solidification/Stabilization Technologies

Solidification/stabilization involves methods to seal the contaminated soil, sediment, or sludge in a solid, stable mass that results in a reduction of contaminant mobility. Such methods can also be used to stabilize a waste to facilitate material handling. These techniques are applicable to metals and radionuclides, but are generally not applicable to high concentrations of the more mobile organic compounds. Solidification/stabilization process options include:

- Cement-/pozzolan-based solidification
- Thermoplastic solidification
- Organic polymer stabilization
- Vitrification
- In situ (cement-based) solidification
- In situ vitrification.

Cement-/Pozzolan-Based Solidification Process Option

This process option is conducted by mixing contaminated soil with a pozzolan. Pozzolans consist of cement, flyash, kiln dust, lime, etc. Pozzolan-based solidification is effective in treating soil,

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sediment, and residue and sludge from treatment processes which are contaminated with organics such as PCBs and polycyclic aromatic hydrocarbons (PAHs), heavy metals, and radionuclides. The mobility of the contaminants is reduced by binding the chemical into a solid matrix which is resistant to leaching. Typically, solidification occurs at high pHs where most metals become less soluble. Organic contaminants can be bound in the solid matrix using various additives such as organophilic compounds. Equipment used for solidification is similar to that used for the cement industry. A solidification process would include a feed system, mixing vessels, and a curing area. The solidified material can be formed into monolithic blocks or can be made into a material with a consistency of soil-cement. Pozzolan solidification is a viable treatment option for radionuclides, inorganics, and some organics and will be retained for further evaluation.

Thermoplastic Solidification Process Option

Thermoplastic solidification involves sealing a waste in a matrix by the addition of a binder. The binder material may be asphalt, bitumen, paraffin, sulfur cement, polystyrene, or polyethylene. The waste is dried, heated, and mixed with a heated binder material. The waste-binder mixture is then heated to 266°F to 500°F and placed in a container or mold where it solidifies as it cools. This process is considered potentially applicable to soil, sediment and treatment process residues and will be retained for further evaluation.

Organic Polymer Stabilization Process Option

This process involves mixing contaminated soil with an organic polymer and catalyst to form a stable solid. The organic polymer may consist of urea-formaldehyde, polyesters, phenolics, and melanine. These thermosetting resins become hardened when heated and resist subsequent heating and cooling cycles. This process is considered potentially applicable to soil, sediment, and treatment process residues and will be retained for further evaluation.

Vitrification Process Option

Vitrification is a thermal treatment process that solidifies the waste into a glassy, solid matrix resistant to leaching. The vitrification of the waste material is achieved in a reaction chamber in which high temperature is used to reduce toxic organic compounds to elemental gases and carbon. The inorganic contaminants are either entrained in the glass and siliceous melts or are volatilized at the high temperatures in the reaction chamber. Vitrification is potentially applicable to soil, sediment, and treatment process residues and will be retained for further consideration.

In Situ (Cement-Based) Solidification Process Option

In situ solidification is conducted by mixing cement, quicklime or other grouting materials with soil using augers or backhoes. The deep soil mixing technique allows direct application of cement-based stabilizing agents, using mixing paddles and augers, that blend the soil with the stabilizing agent fed

through the center of the shaft. The result of the in situ solidification is a monolithic block that extends through the area of contamination. Because of heterogeneous subsurface conditions and possible subsurface obstructions such as utilities and building foundations at the FEMP site, it is unlikely that adequate mixing could be achieved for this process to be effective. Therefore, in situ solidification will be eliminated from further consideration.

In Situ Vitrification Process Option

In situ vitrification is a process of melting waste and soil in place to bind the waste in a glassy, solid matrix which is resistant to leaching and weathering. In situ vitrification is conducted by inserting large electrodes into the soil to the desired treatment depth. An electric current is applied to the electrodes which results in the soil being heated to temperatures ranging from 2900°F to 3600°F. As the soil is heated, organics are destroyed by pyrolysis and inorganic materials are dissolved into or are encapsulated in the vitrified mass. Currently there are no in situ vitrification applications of this magnitude in existence due to the overwhelming amounts of energy that would be consumed. At the required temperatures steam generation and volatile organic production would be major problems. Therefore, in situ vitrification will also be eliminated from further consideration.

M.3.5.5 Thermal Treatment Technologies

Thermal treatment uses elevated temperature to volatilize or destroy organic compounds. Soil from hazardous waste management units (HWMUs) within Operable Unit 5 contain solvent wastes for which thermal treatment is applicable. Except for the plasma centrifugal furnace process option which would be considered a primary treatment option, the remaining thermal treatment technologies would be considered as support processes since they are used to remove organic contaminants prior to the treatment of metals and radionuclides in soil. Thermal treatment processes evaluated include:

- Thermal desorption
- Rotary kiln incineration
- Fluidized bed combustion
- Circulating bed combustion
- Radio frequency heating
- Infrared incineration
- Plasma centrifugal furnace.

Thermal Desorption Process Option

Thermal desorption involves treating soil with organic contamination at low temperatures to promote volatilization of the chemicals. The vapor phase is then treated by incineration or carbon adsorption. This process option will not treat metals or radionuclides, although it can be used as a pretreatment step to remove organics. Thermal desorption is therefore retained for further consideration as a support option for treatment of organics in soil, sediment and treatment process residuals.

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Rotary Kiln Incineration Process Option

Rotary kiln incineration uses a rotating refractory-lined cylinder to destroy organic material. Waste material is rotated, causing turbulence and agitation while heated combustion air dries and incinerates the waste. Normal operating temperatures vary from 1500°F to 3000°F. This technology will not treat inorganics or radionuclides although it can be used as a pretreatment step to remove organics. It is therefore retained for further consideration as a support option for treatment of organics in soil, sediment and treatment process residuals.

Fluidized Bed Combustion Process Option

Fluidized bed combustors are vertical lined chambers containing an inert material, usually sand. Air is forced through a supporting distribution plate at a rate sufficient to cause the inert material to display fluid properties. Waste is injected into the bed and combustion occurs at normal operating temperatures varying from 850°F to 2100°F. Waste materials with densities greater than the inert material cannot be treated. Volatile organics contained in the soil will be destroyed. This technology will not treat inorganic contaminants or radionuclides although it can be used as a pretreatment step to remove organics. Fluidized bed combustion is therefore retained for further consideration as a support option for treatment of organics in soil, sediment and treatment process residuals.

Circulating Bed Combustion Process Option

Circulating bed combustion is similar to fluidized bed combustion, except that the system operates at higher air velocities which allows the system to operate at lower temperatures. Normal operating temperature is approximately 850°F. This technology will not treat inorganic contaminants or radionuclides although it can be used as a pretreatment step to remove organics. It is therefore retained for further consideration as a support option for treatment of organics in soil, sediment and treatment process residuals.

Radio Frequency Heating Process Option

Radio frequency heating is primarily an in situ treatment in which soil is heated between 200°F and 1000°F by exciting electrodes placed in the ground with radio frequency energy. Organics are vaporized and collected at the surface for treatment. This technology will treat organics but will not treat inorganics or radionuclides; it will still be necessary to excavate the soil. Therefore, this process option is eliminated from further consideration.

Infrared Incineration Process Option

Infrared thermal units use silicon carbide elements to generate thermal radiation beyond the red end of the visible spectrum. Materials to be treated pass through the unit on a belt and are exposed to the radiation. Off-gasses pass into a secondary chamber for further infrared radiation and increased retention time. Operating temperatures are 1400°F to 1600°F in the primary and secondary

chambers, respectively. This technology will not treat inorganics or radionuclides, although it can be used as a pretreatment step to remove organics. It is therefore retained for further consideration as a support option for treatment of organics in soil, sediment and treatment process residuals.

Plasma Centrifugal Furnace Process Option

Soil treated using the plasma centrifugal furnace process is detoxified by the use of heat to vaporize organic contaminants and immobilize metals and radionuclides in a nonleachable glass-like matrix. The plasma centrifugal furnace uses the heat from the plasma torch to create a molten bath. Metals and radionuclides are not detoxified by the use of this process; however, their mobility would be reduced by being incorporated into the final residue which is a glass matrix. The plasma centrifugal furnace option has been retained for further evaluation as a primary process option because mixed radioactive wastes can potentially be handled by this type of treatment method, and it is applicable to soil, sediment and treatment process residuals.

M.3.6 STORAGE

Temporary storage of contaminated soil, sediment, treatment process residuals, and nonrecoverable debris would be required after these materials are removed and awaiting final treatment or disposal actions.

M.3.6.1 Intermediate Storage Technologies

Short-term storage of the waste in a storage facility would be required as an intermediate process for contaminated wastes designated for ex situ remediation. This technology includes only one process option which is a central storage facility (CSF).

Central Storage Facility Process Option

This option assumes that contaminated wastes would be staged and packaged at an on-property CSF before treatment or shipment to an appropriate disposal facility. The storage facility must be able to handle both bulk and containerized wastes as well as nonrecoverable debris in accordance with DOE Removal Action No. 17. For the purposes of this screening process, a designated on-property CSF is considered to be potentially applicable for contaminated soil and sediment, treatment process residuals, and nonrecoverable debris and is retained for further consideration.

M.3.7 DISPOSAL

Disposal options evaluated include on-property and off-site disposal technologies and waste transportation technologies.

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M.3.7.1 On-Property Disposal Technologies

The three process options evaluated for on-property disposal are:

- Backfilling
- Engineered disposal cell
- Consolidation.

Backfilling Process Option

Backfilling of excavations with clean or slightly contaminated site soil is an inexpensive disposal option, provided that contaminant levels in the backfilled materials will attain the required remediation goals. Backfilling is potentially applicable to site soil and is retained for further consideration.

Engineered Disposal Cell Process Option

This process option would involve constructing an on-property engineered disposal cell. This would provide permanent on-property storage of contaminated soil and sediment, nonrecoverable debris, and treatment process residuals. The representative disposal cell design would incorporate performance requirements from DOE, Ohio EPA (OEPA), and the Nuclear Regulatory Commission (for low-level waste), and would meet the 1000 year ARAR-based design life requirement. It is anticipated that the disposal cell would be sited in the former production area.

The cell would be designed such that the hydraulic permeability of the bottom liner is slightly greater than that of the cap in order to minimize the potential for a "bathtub effect." The infiltration rate through the cell would be protective of the Great Miami Aquifer. Runoff from the cell cap would be controlled by a storm water diversion channel and the cell would also incorporate a leachate collection system. It is anticipated that the disposal cell would be constructed and filled in phases. The on-property engineered disposal cell is potentially applicable and is retained for further consideration in the formation of remedial alternatives.

Consolidation Process Option

On-property consolidation involves consolidation of slightly contaminated soil and sediment at an on-property central location. Because it is likely that slightly contaminated soil will remain on site with institutional controls, excavated soil and sediment that are protective of the Great Miami Aquifer may be consolidated to minimize the area remaining under federal ownership. Consolidation would meet the 1000 year ARAR-based design life requirement. It would also maximize the area that could be released for restricted or unrestricted use.

Siting of the consolidation area must take into account several factors including future site use, site geology, remediation schedules and location of possible disposal cells. It is anticipated that the

former production area will be the site of consolidation because it is unlikely that this area will be released for any type of use and the majority of the contaminated soil would originate in this area.

Consolidation material will consist of slightly contaminated soil and sediment which will be transported to the consolidation area, unloaded, and placed at grade. This material will be covered with a cap or other cover. It is anticipated that the consolidation area will be built and filled in phases. On-property consolidation is applicable to slightly contaminated soil and sediment, and is retained for further consideration.

M.3.7.2 Off-Site Disposal Technologies

Two process options are evaluated for this technology:

- Nevada Test Site (NTS)
- Permitted commercial disposal facility.

Disposal at Nevada Test Site as a Process Option

Off-site disposal at NTS involves hauling treated and/or untreated contaminated soil, sediment, non-recoverable debris and/or contaminated treatment residuals to an off-site disposal facility that can accept radiological waste materials. The NTS is a DOE facility that is currently accepting low-level radioactive waste from the FEMP site. Off-site disposal at NTS is potentially applicable to soil, sediment, nonrecoverable debris, and treatment process residuals and is retained for further evaluation.

Disposal at a Permitted Commercial Disposal Facility as a Process Option

Off-site disposal at a permitted commercial facility involves hauling treated and/or untreated contaminated soil, sediment, nonrecoverable debris and/or contaminated treatment residuals to an off-site commercial facility which can accept radiological waste materials. A representative commercial facility in Utah, Envirocare, is available to accept low-level radioactive waste and mixed waste. Off-site disposal at a permitted commercial facility such as Envirocare or an equivalent is potentially applicable to soil, sediment, nonrecoverable debris, and treatment process residuals, and is retained for further evaluation.

M.3.7.3 Waste Transportation Technologies

The two process options considered for waste transportation are:

- Truck transport
- Rail transport.

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Truck Transport Process Option

Truck transport can easily offer portal-to-portal service with the road system available at the FEMP site. The primary disadvantages with this process option are the relatively undeveloped and heavily traveled roads near the FEMP site and the higher cost compared to rail transport. Truck transportation is applicable as a support action to on- and off-site disposal and will be carried further in the evaluation of process options.

Rail Transport Process Option

The FEMP can readily support rail transportation by using existing on-site rail spurs. Some off-site disposal options have facilities with the capability of receiving the waste by rail. Transportation to NTS may require a combination of truck and rail transport. Contaminated material shipped by rail to NTS would go through the Las Vegas, Nevada terminal. Transportation to the commercial facility in Utah can use rail for the entire trip. Rail transportation is applicable as a support action to off-site disposal and will be carried further in the evaluation of process options.

M.4.0 EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

In this section of Appendix M, the technologies and process options which have passed the initial screening are considered for further evaluation. The purpose of the evaluation is to obtain a reasonable number of process options to combine into remedial alternatives in Section 4.0 of this FS. The technologies and process options remaining after the initial screening for perched and Great Miami Aquifer groundwater were evaluated based on effectiveness, implementability, and cost. The process options within each technology type were then compared, and the preferred or representative process options were selected for incorporation into remedial action alternatives.

Table M.4-1 summarizes the results of the evaluation of technologies and process options for perched and Great Miami Aquifer groundwater. Shaded areas in this table represent those process options and/or technologies that have been eliminated from further consideration. Tables M.4-2 and M.4-3 present the technologies and process options that will be retained for consideration in the development of remedial alternatives for perched groundwater and Great Miami Aquifer groundwater, respectively. In these tables, the technologies are organized according to the general response actions developed in Section 3.1 of this FS. Retained process options are listed by type (primary or support, and representative).

Following is a description of the evaluation process for each of the groundwater technologies and process options which passed the initial screening procedure in Section M.2.0.

M.4.1 NO ACTION

The no-action general response is retained for development into an alternative as required by CERCLA. It is considered to provide a baseline level to which other remedial technologies and alternatives can be compared. Under this scenario, no containment, removal, or treatment of the contaminants in any groundwater would occur. Additionally, it is assumed that any existing institutional controls would be discontinued and the property released for unrestricted use.

- Effectiveness: The no-action response would not achieve any of the remedial action objectives nor provide for the adequate long-term protection of human health. This response would not attain human health-based goals or comply with ARARs. The contaminated groundwater plumes will continue to enlarge and thereby contaminate currently unaffected areas. The no-action option would provide no additional reduction in the toxicity, mobility, or volume of contaminants in the Great Miami Aquifer and perched groundwater other than that offered by the natural environment. Over time, the

TABLE M.4-1
SUMMARY OF EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
(Shaded Process Options and/or Technologies Have Been Eliminated From Further Consideration)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
No Action	None	Not Applicable	G,P	Not effective in protection of public health or the environment.	No actions would be implemented.	None.	None.
Institutional Controls	Monitoring	Groundwater Monitoring	G,P	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of groundwater recovery system.	Readily implementable.	Low; new wells may need to be installed.	Low; includes maintenance, sampling and analysis.
		Leachate Monitoring	P	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of perched water remedial actions.	Readily implementable.	Low; new collection sumps may need to be constructed.	Low; includes sampling and analysis.
		Surface Water Monitoring	G,P	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of water treatment system.	Readily implementable.	Low; includes installation of automated monitoring system.	Low; includes sampling and analysis.
	Access/Use Restrictions	Alternate Water Supply	G	Indirectly meets human health objectives by limiting exposure; does not meet environmental objectives since contaminants are left in place.	Extension of existing distribution system is readily implementable and in progress.	Moderate; includes pump stations, trunk and distribution lines.	Low to moderate; includes well and line maintenance and water monitoring.

[a]NOTE: G - Great Miami Aquifer Groundwater; P - Perched Groundwater

TABLE M.4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Institutional Controls (continued)	Access/Use Restrictions (continued)	Physical Barriers	G,P	Indirectly meets human health objectives by limiting access; does not meet environmental objectives since contaminants are left in place.	Readily implementable.	Low; includes materials and installation, and is dependent on the extent of area to be enclosed.	Negligible.
		Deed Restrictions	G,P	Indirectly meets human health objectives by reducing exposure; does not meet environmental objectives since contaminants are left in place.	Readily implementable within property; not implementable for off property restrictions.	Negligible.	Negligible.
		Continued Federal Ownership	G,P	Indirectly meets human health objectives by reducing exposure; does not meet environmental objectives since contaminants are left in place.	Readily implementable; maintains status quo.	Negligible.	Negligible.
Containment	Capping	Multilayer Cap	G,P	Does not reduce toxicity, mobility or volume of contaminants; reduces the potential for migration by limiting infiltration and erosion.	Materials, equipment, and skilled labor are readily available.	Moderate; includes materials and installation, and depends upon area to be enclosed.	Low; includes periodic inspections, maintenance and repairs.

[a]NOTE: G - Great Miami Aquifer Groundwater; P - Perched Groundwater

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TABLE M.4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Containment (continued)	Subsurface Water Control	Vertical Slurry Walls	P	Does not reduce toxicity, mobility or volume of contaminants; reduces the potential for lateral migration.	Materials, equipment, and labor are readily available; more difficult at depths greater than 75 feet.	Moderate; includes trench construction, backfilling, and depends upon length and depth required.	Low; includes periodic inspections and repairs.
		Horizontal Slurry Barrier	P	Does not reduce toxicity, mobility or volume of contaminants; reduces the potenual for vertical migration; difficult to determine integrity.	Construction involves special techniques and equipment; limited number of vendors.	High; includes slurry injection into predrilled holes, special equipment mobilization; depends on depth and area of barrier.	Low; includes periodic repairs of the barrier and monitoring its performance.
		Subsurface Drains	P	Does not reduce toxicity, mobility or volume of contaminants; reduces the potential for lateral migration	Constructing drain systems beneath contaminated soil can be difficult; materials and equipment are readily available.	Low to moderate; includes installation of conduit, pumps, and leachate collection tanks or sumps.	Low; includes pump maintenance and monitoring costs.
		Sheet Piling	P	Does not reduce toxicity, mobility or volume of contaminants; potential for reducing lateral migration is questionable.	Materials, equipment and labor are readily available.	Low; includes materials and installation, and depends on length and depth of piling required.	Negligible.
		Pumping Wells	G	Does not reduce toxicity or mobility of contaminants; reduces contaminant volume and potential for migration.	Construction simple; materials and equipment are readily available.	Low to moderate; includes construction of new pumping wells.	Low to moderate; includes operation and maintenance.

[a]NOTE: G - Great Miami Aquifer Groundwater; P - Perched Groundwater

TABLE M.4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Removal	Subsurface Water Extraction	Vertical Extraction Wells	G,P	Does not reduce toxicity or mobility of contaminants, but does reduce volume and potential for migration.	Equipment and materials are readily available.	Low to moderate; includes installation of new wells and pumps.	Low to moderate; includes electricity and maintenance of wells, pumps and other equipment.
		Directional Extraction Wells	G,P	Does not reduce toxicity or mobility of contaminants, but does reduce the potential for migration.	Equipment and materials are readily available; more difficult to construct than vertical extraction wells.	Moderate; more costly than vertical wells; includes installation of new wells and pumps.	Moderate; includes electricity plus maintenance of wells, pumps and other equipment.
		Collection Trench/French Drain	P	Effective in removing contaminated media so it is no longer a threat to human health and the environment; decrease in effectiveness when depths exceed 40 feet.	Equipment and materials are readily available; skilled labor required as trenching depths approach 40 feet.	Moderate; includes construction of trenches and associated collection sumps.	Low; includes maintenance and periodic inspections.
		Excavation	P	Effective in removing contaminated media so it is no longer a threat to human health and the environment.	Equipment and materials are readily available; conventional techniques readily implementable.	Low; includes skilled labor and equipment.	Negligible.
		Electroosmosis	P	May be effective in removing inorganic constituents of concern; very limited application at hazardous waste sites.	Equipment and materials are readily available; however, skilled labor required; tanks, buildings or utilities would interfere with process.	Moderate; includes installation of system and construction of associated collection sumps.	High; includes maintenance, inspections, plus possible excessive electrical costs.

[a]NOTE: G - Great Miami Aquifer Groundwater; P - Perched Groundwater

TABLE M.4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment	In Situ	Vapor Sparging	G	Questionable effectiveness issues; reliability of process at required depths and ability of natural carbonates to mobilize uranium.	Materials, equipment and labor are readily available; injection permit may be difficult to obtain.	Moderate; includes air injection fans, ducts and additional injection wells if required.	Moderate; includes electricity, monitoring, bulk CO_3 and equipment maintenance.
	Physical	Equalization	G,P	Effective support process option for most treatment processes.	Materials and equipment are readily available.	Low; includes installation of tanks, sumps, and mixers.	Low; includes mixer maintenance and electricity.
		Sedimentation/ Clarification	G,P	Effective support process for chemical precipitation; improves removal of inorganics and radionuclides.	Materials and equipment are readily available; thickened sludges must be dewatered before off-site disposal.	Moderate; includes installation of clarifier/thickener system.	Low; includes electricity and maintenance for pumps and agitators.
		Ultrafiltration	G,P	Emerging technology in regard to wastewater applications; not as reliable as multimedia filtration for the removal of suspended solids.	Materials and specialized equipment are readily available; skilled labor required to implement.	High; includes pilot studies, and design and construction of the system.	High; includes equipment maintenance, membrane replacement, chemical additions and electricity.
		Multimedia Filtration	G,P	Effective support option for many treatment processes such as reverse osmosis, ion exchange, carbon adsorption; removes only suspended contaminants in water media.	Materials and equipment are readily available.	Low; includes equipment and filtration media.	Low; includes filter maintenance and occasional replacement of filter media.

[a]NOTE: G - Great Miami Aquifer Groundwater; P - Perched Groundwater

TABLE M.4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (continued)	Physical (continued)	Reverse Osmosis	G,P	Reliable treatment process for dissolved organics, inorganics and metals; pH adjustment, filtration, and removal of certain organics are required pretreatment steps.	Materials and specialized equipment are readily available; membranes are subject to deterioration; disposal of sizable liquid reject stream is difficult.	High; includes pilot studies, and design and construction of the system.	High; includes membrane replacement, chemical additions, handling of reject stream and electricity.
		Volatilization	G,P	Reliable treatment process for removal of volatile organics in wastewater; off-gas requires treatment.	Materials and equipment are readily available; pretreatment of solids, iron and certain salts is needed to prevent packing material from clogging.	Moderate; includes the cost of packing material, and installation of the system.	Low to moderate; depends on contaminant loadings, degree of removal and type of off-gas treatment required.
		Adsorption	G,P	Reliable treatment process for removal of low level organics in wastewater; low carbon consumption expected.	Materials and equipment are readily available; spent carbon must be disposed of; regeneration not practiced because of adsorbed radioactivity.	Moderate; includes activated carbon cost, plus design and construction of the system.	Moderate; depends on carbon usage rate which is a function of contaminant loadings.
	Chemical	Ion Exchange	G,P	Reliable treatment process for removal of low level ionic contaminant species such as metals, inorganics and radionuclides.	Materials and equipment are readily available; spent resin may be reused after regeneration or disposed of.	Moderate; includes initial resin cost plus design and installation of the system.	Moderate; includes cost of replacement resin and regeneration chemicals.

[a]NOTE: G - Great Miami Aquifer Groundwater; P - Perched Groundwater

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TABLE M.4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (continued)	Chemical (continued)	Electrodialysis Reversal	G,P	Has not been proven to be effective in the treatment of uranium and radionuclides; would require treatability study to verify applicability.	Materials and equipment are available; disposal of sizable brine reject stream is difficult.	High; includes extensive studies, and design and installation of the system.	High; includes cost of membrane replacement, electricity and handling of brine reject stream.
		Coagulation/ Flocculation	G,P	Effective treatment process for the removal of metals, inorganics and radionuclides in the form of small colloidal particles.	Materials, chemicals and equipment are readily available.	Low; includes feed tanks, pumps and mixers.	Low; includes maintenance of equipment, and depends on types of chemicals used.
		Neutralization/ pH Adjustment	G,P	A proven and reliable means of balancing or changing the pH in a water media; often used as a pretreatment step for many treatment options.	Materials, chemicals and equipment are readily available.	Low; includes feed tanks, pumps and mixers.	Low; includes equipment maintenance and replacement chemicals.
		Chemical Precipitation	P	A proven and reliable means of removing insoluble metals and radionuclides from wastewater through the use of coagulants.	Materials, chemicals and equipment are readily available.	Low; includes feed tanks, pumps and mixers.	Moderate; includes maintenance of equipment, and depends on types of chemicals used.
		Enhanced Oxidation	G,P	Innovative technology that is contaminant specific in its effectiveness; would require treatability study to verify applicability.	Implementable; however, equipment is not readily available; pretreatment by filtration required to prevent lamp fouling; controls needed to prevent peroxide releases.	High; includes extensive studies, and design and installation of the system.	Moderate to high; depends on flow rate and contaminant loadings; very high energy requirements.

[a]NOTE: G - Great Miami Aquifer Groundwater; P - Perched Groundwater

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TABLE M.4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (continued)	Chemical (continued)	Chemical Reduction	G,P	Typically most effective for wastewater containing heavy metal concentrations; most common application converts hexavalent chromium to the trivalent state.	Materials, chemicals and equipment are readily available; however, processes which eliminate pH reduction step are more difficult to implement.	Moderate; includes feed tanks, pumps and mixers plus installation of the system.	Low to moderate; includes maintenance of equipment, and depends on types of chemicals used.
	Physical/ Chemical	Treatment by Advanced Wastewater Treatment Facility (AWWT)	P	Reliable treatment processes for removal of organics, metals, uranium and other radionuclides.	Readily implementable as it is currently under construction.	Negligible; since system is already designed and in the construction phase.	High; includes resin, filter media, chemical replacement and disposal of process residues.
	Biological	Biosorption	G,P	Innovative technology that removes metals, uranium and other radionuclides from wastewater; modification of the ion exchange process.	Difficult to implement as it is a proprietary technique; availability of equipment and skilled workers could be limited.	High; includes pilot studies, and design and installation of the system.	High; includes cost of replacement resin and disposal of residuals.

[a]NOTE: G - Great Miami Aquifer Groundwater; P - Perched Groundwater

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TABLE M.4-1
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Disposal/ Discharge	On-Property	Beneficial Reuse	G,P	Effective if treated to the necessary process standards; reduces volume of groundwater needed to be disposed of by other options.	Readily implementable.	Low; requires a make up tank, pumps, and a distribution line to be installed.	Low; includes equipment maintenance and line inspections.
		Discharge to Paddys Run	G,P	Imposed discharge limits would be protective of human health and the environment; capacity of Paddys Run may be limited.	Implementable; would require construction of treated effluent discharge line; Paddys Run limits more stringent than those for the Great Miami River.	Low; includes the construction of a discharge line from the treatment facilities to Paddys Run.	Low; includes maintenance and monitoring costs.
	On-Property/ Off-Property	Surface/ Subsurface Discharge	G	Imposed discharge limits would be protective of human health and the environment; effective in reducing remediation time in a pump and treat system by increasing flow through the aquifer.	May be difficult to achieve a closed system; difficult to obtain permission to inject into a sole source drinking water aquifer; limits more stringent than those for surface water discharge.	Moderate; includes installation of new injection wells and pumps; would cost more than surface water discharge.	Moderate; includes maintenance of wells and pumps, electricity and sampling and analysis.
	Off-Property	Discharge to Great Miami River	G,P	Imposed discharge limits would be protective of human health and the environment.	Easily implementable; construction of enclosed pipeline to Great Miami River is completed; need to connect effluent lines from treatment plants.	Low; includes connecting treatment discharge lines to enclosed pipeline.	Low; includes maintenance and monitoring costs.

[a]NOTE: G - Great Miami Aquifer Groundwater; P - Perched Groundwater

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TABLE M.4-2

SUMMARY OF RETAINED PERCHED GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

General Response Action	Remedial Technology	Process Option	Primary	Support	Representative Process Option [a]
No Action	None	Not applicable	X		
Institutional Controls	Monitoring	Groundwater monitoring		X	X
		Leachate monitoring		X	X
		Surface water monitoring		X	X
	Access/Use Restrictions	Physical barriers		X	X
		Deed restrictions		X	X
		Continued Federal ownership		X	X
Containment	Capping	Multilayer cap	X		X
	Subsurface Water Control	Vertical slurry walls		X	
Removal	Subsurface Water Extraction	Vertical extraction wells		X	
		Collection trench/ French drain		X	
		Excavation	X		X
Treatment	Physical	Equalization		X	
		Sedimentation/clarification		X	
		Multimedia filtration		X	
		Adsorption	X		
	Chemical	Ion exchange	X		
		Coagulation/flocculation		X	
		Neutralization (pH adjustment)		X	
		Chemical precipitation	X		
	Physical/Chemical	Treatment by Advanced Wastewater Treatment Facility (AWWT)	X		X
Disposal/ Discharge	On-Property	Beneficial reuse		X	X
	Off-Property	Discharge to the Great Miami River	X		X

[a] The representative process options have been selected for incorporation into the remedial alternatives. Their selection does not preclude the use of the other retained process options in the remedial design.

TABLE M.4-3

SUMMARY OF RETAINED GREAT MIAMI AQUIFER GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

General Response Action	Remedial Technology	Process Option	Primary	Support	Representative Process Option[a]
No Action	None	Not applicable	X		
Institutional Controls	Monitoring	Groundwater monitoring		X	X
		Surface water monitoring		X	X
	Access/Use Restrictions	Alternate water supply		X	X
		Physical barriers		X	X
		Deed restrictions		X	X
		Continued Federal ownership		X	X
Containment	Capping	Multilayer cap	X		X
Removal	Subsurface Water Extraction	Vertical extraction wells	X		X
Treatment	In Situ	Vapor sparging		X	
	Physical	Equalization		X	X
		Sedimentation/clarification		X	X
		Multimedia filtration		X	X
		Adsorption	X		X
	Chemical	Ion exchange	X		X
		Coagulation/flocculation		X	X
		Neutralization (pH adjustment)		X	X
Disposal/ Discharge	On-Property	Beneficial reuse		X	X
	On-Property/ Off-Property	Surface/subsurface discharge		X	
	Off-Property	Discharge to the Great Miami River	X		X

[a] The representative process options have been selected for incorporation into the remedial alternatives. Their selection does not preclude the use of the other retained process options in the remedial design.

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potential for exposure would increase as contaminants continue to be released to the groundwater. The degree of contamination in the groundwater would decrease through natural attenuation and dilution over a long period of time (i.e., greater than 1000 years) provided that no new sources of contamination were generated.

- Implementability: There are no implementability considerations associated with the no-action scenario.

- Cost: Because no action would be taken at the site, there would be no capital or operations and maintenance (O&M) costs.

As required by the NCP, the no-action response is retained for further evaluation as a baseline comparison for other remedial action alternatives.

M.4.2 INSTITUTIONAL CONTROLS

The technologies considered for institutional controls include monitoring and access/use restrictions.

M.4.2.1 Monitoring Technologies

Process options evaluated under the monitoring technology include:

- Groundwater monitoring
- Leachate monitoring
- Surface water monitoring.

Groundwater Monitoring

Groundwater monitoring is applicable to both perched and Great Miami Aquifer groundwater. Sampling and analysis of groundwater throughout the area of potential contamination could be used to evaluate migration of contaminants, as well as the potential for contamination of on-site and nearby residential, municipal, and commercial wells. Monitoring of both perched and Great Miami Aquifer groundwater can also be helpful in evaluating the progress of other remedial activities.

- Effectiveness: Groundwater monitoring would not reduce the toxicity, mobility, or volume of contaminants in the Great Miami Aquifer or perched groundwater. Also, monitoring would not provide any additional protection of the environment since the contaminant plumes would continue to spread into uncontaminated or less contaminated areas. By serving as an early warning detection mechanism, periodic groundwater monitoring would enable users to discontinue use of groundwater if a threat of contamination arose in the area. Monitoring will also be helpful in measuring and evaluating the effectiveness of groundwater recovery systems. Potential impact on human health and the environment during construction and implementation would be negligible. Exposure for sampling and analytical personnel would also be negligible.

- Implementability: A large number of monitoring wells currently exist within the FEMP site boundaries and on neighboring properties. Additional wells could be installed if needed since the required equipment and services are readily available. Minimal administrative complexities, including permit applications, are envisioned for monitoring well installation.

- Cost: For groundwater monitoring only, capital and O&M costs would be relatively low. Capital costs would include the installation of additional monitoring wells. O&M costs would include well maintenance, sampling, laboratory analysis, and data validation/management.

Groundwater monitoring would be effective and readily implementable in facilitating the observation of contaminant migration but not in controlling it. As a result, it will be retained as a support option to be used in conjunction with other process options in the formation of remedial alternatives.

Leachate Monitoring

Leachate monitoring is applicable to perched groundwater. Sampling and analysis of on-property perched leachate streams, where perched groundwater discharges to surface water, could be used to evaluate the progress of other remedial activities.

- Effectiveness: Leachate monitoring would not reduce the toxicity, mobility, or volume of contaminants in the perched groundwater. Also, monitoring would not provide any additional protection of the environment since the contaminated perched groundwater would continue to migrate into the Great Miami Aquifer. Monitoring would be helpful in measuring and evaluating the effectiveness of perched water remedial actions. Potential impacts on human health and the environment during construction and implementation would be negligible. Exposure for sampling and analytical personnel would also be negligible.

- Implementability: Leachate monitoring is easily implementable. It only involves the sampling and analysis of collected leachate seeps or streams. Equipment and services are readily available.

- Cost: For leachate monitoring only, capital and O&M costs would be relatively low. Capital costs would include the possible installation of a few collection sumps. O&M costs would include sampling, laboratory analysis, and data validation/management.

Leachate monitoring would be effective in observing, but not controlling contaminant migration. Leachate monitoring would be implementable. As a result, leachate monitoring will be retained as a support option for perched groundwater to be used in conjunction with other process options in the formation of remedial alternatives.

Surface Water Monitoring

Surface water monitoring is applicable to perched and Great Miami Aquifer groundwater which has been removed and brought to the surface for treatment. Sampling and analysis of treated groundwater, process wastewater, and collected storm water would be required for any water discharged to local surface streams. Surface water monitoring can also be helpful in evaluating potential surface water contaminant migration and the effectiveness of remedial treatment activities.

- Effectiveness: Surface water monitoring would not reduce the toxicity, mobility, or volume of contaminants in the surface water. Also, monitoring would not provide any additional protection of the environment since the contaminated surface water would continue to migrate to off-site areas. Monitoring will be helpful in measuring and evaluating the effectiveness of treatment for all groundwater and other wastewater. Potential impacts on human health and the environment during implementation would be negligible. Exposure for sampling and analytical personnel would also be negligible.

- Implementability: Surface water monitoring is implementable. Discharges of treated effluent typically require continuous monitoring of the discharge stream for flow rate and pH, as well as composite sampling and analysis for other contaminants. These monitoring systems are fairly commonplace and are often built into the treatment plant design. Equipment and services are readily available. While CERCLA response actions are exempt from administrative requirements like NPDES permits, the substantive information typically found on permit applications would be required to be provided to the state for any proposed point source discharges to the Great Miami River or Paddys Run.

- Cost: For surface water monitoring only, capital and O&M costs would be relatively low. Capital costs would include the installation of an automated sampling and monitoring system. O&M costs would include labor to collect samples for laboratory analysis, and data validation and management.

Surface water monitoring would be effective. Treatment effectiveness and contaminant migration could be observed, but not controlled. Monitoring would be implementable. As a result, it will be retained as a support option to be used in conjunction with other process options in the formation of alternatives.

M.4.2.2 Access/Use Restrictions

Process options evaluated under access/use restrictions include:

- Alternate water supply
- Physical barriers
- Deed restrictions
- Continued federal ownership.

Alternate Water Supply

The alternate water supply is applicable to off-property Great Miami Aquifer groundwater. Alternate water supplies would also be provided to potential future FEMP property users if areas were released for unrestricted use following remedial actions. At this time, alternate water supply or point-of-use treatment systems are being supplied to residences which have been affected by the contaminant migration in the South Plume area. The FEMP is currently participating with Hamilton County, Ohio in the installation of a public water distribution system to homeowners potentially impacted by the contaminated plume. Continued use or expansion of the water supply system could be used as a process in support of the active aquifer restoration or groundwater containment options.

- Effectiveness: Alternate water supplies would not reduce the toxicity, mobility, or volume of contaminants in the groundwater. However, by supplying other water sources, this process option would reduce the potential long-term risk to human health associated with ingestion or inhalation of groundwater contaminants by limiting exposure. Potential short-term impact on human health and the environment during construction and implementation of a distribution system would be negligible.

- Implementability: The extension of an existing distribution system to affected areas off the FEMP property is currently in progress. The continuation of supplying bottled water to affected well users until the extended distribution system is completed has been easily implemented as an interim measure. The extension of this proposed system, as required, is implementable.

- Cost: For the alternate water supply option, capital costs associated with system expansion would be moderate while O&M costs would be low to moderate. Capital costs would include supply wells, trunk lines, pump stations, and distribution lines, plus all excavation and construction costs. O&M costs would include well and line operation and maintenance, water monitoring, and data management.

Alternate water supplies would be effective and will be retained for further consideration as a support option for Great Miami Aquifer groundwater to be used in conjunction with other process options in the formation of alternatives.

Physical Barriers

Fencing and security forces are currently employed as physical barriers around the entire FEMP property. Because treated Great Miami Aquifer and perched groundwater may be discharged off-property, a totally enclosed outfall line has been constructed. Also, because monitoring wells extend beyond property boundaries, physical barriers such as fences, gates, ropes, and signs must be employed as appropriate for those monitoring wells.

- Effectiveness: Physical barriers would not reduce the toxicity, mobility, or volume of contaminants in the water media; however, they would reduce the potential risk to

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human health by limiting potential exposure to contamination. Potential impact on human health and the environment during construction and implementation would be negligible.

- Implementability: Physical barriers can be constructed quickly and safely. Equipment and services are readily available. Approval from regulatory agencies is not required.

- Cost: Capital costs would be low. Capital costs would only include the cost of the barrier itself and installation costs. O&M costs would be negligible.

Physical barriers would be effective and are easily implementable. This support process option will be retained to support other remedial actions for all groundwater in the formation of alternatives.

Deed Restrictions

Deed restrictions limit the use of land during and after remediation by placing restrictions on property deeds. These restrictions may limit future activities, such as placement of new wells or certain types of construction. This process option would be applicable to all groundwater.

- Effectiveness: Deed restrictions could attempt to ensure that no new wells would be installed in the contaminated plume, thereby reducing the potential risk to human health associated with ingestion or inhalation of groundwater contaminants by limiting exposure. This process option could also be applied to perched groundwater to ensure that it is restricted from certain types of use. However, these restrictions are difficult to enforce without the application of additional controls, and would not reduce the toxicity, mobility, or volume of contaminants in the groundwater.

- Implementability: Deed restrictions could be implemented readily for federally owned land. Obtaining deed restrictions for affected off-property areas would not be implementable.

- Cost: Because no action would be taken at the site, capital and O&M costs would be negligible.

This option may be used to support other technologies to restrict future use of the Great Miami Aquifer and perched groundwater. Deed restrictions will be retained for further consideration in the formation of alternatives.

Continued Federal Ownership

Continued federal ownership is applicable to on-property perched and Great Miami Aquifer groundwater. This process option could restrict or eliminate on-property groundwater usage by the federal government continuing to exercise its rights as the property owner. The property owner would continue custodial oversight of the property through the DOE or another government entity.

Continued federal ownership could be used as a support process to active aquifer restoration or groundwater containment options.

- Effectiveness: Continued federal ownership would not reduce the toxicity, mobility or volume of contaminants in the groundwater; however, it would reduce the potential risk to human health by using property ownership rights to limit potential exposure associated with ingestion or inhalation of contaminants contained in on-property groundwater. This process option would not reduce the potential risks associated with off-property groundwater.

- Implementability: This option is readily implementable as it represents the continuation of the existing situation.

- Cost: Because no action would be taken at the site, capital and O&M costs would be negligible.

Continued federal ownership is not feasible as a stand-alone option because it cannot address off-property groundwater contamination. However, this option may be used in conjunction with other technologies to restrict future uses of the on-property groundwater. This option would also ease the implementation of other institutional controls such as monitoring, deed restrictions, and physical barriers. Continued federal ownership is applicable to both perched and Great Miami Aquifer groundwater and will be retained for further consideration as a support option in the formation of alternatives.

M.4.3 CONTAINMENT

The technologies considered for containment include capping and subsurface water control.

M.4.3.1 Capping Technologies

The only process option evaluated under the capping technology is a multilayer cap.

Multilayer Cap

Multilayer capping involves the installation of a multiple-layer barrier over the surface of the contaminated area. This process option is applicable to perched and Great Miami Aquifer groundwater, where it can be used to control direct contact exposure and reduce the migration of contaminants. The multilayer cap would consist of a combination of low permeability materials such as clay, concrete, asphalt, and synthetic membranes.

The current design standards for mixed low-level radioactive and hazardous waste disposal cell caps commonly include: an outer rock or vegetative layer to minimize erosion and provide for long- term stability; a filter and drainage layer that transmits infiltrated water away from underlying low-

permeability layers to prevent ponding; and an impervious flexible membrane overlying a compacted low-permeability clay layer.

- Effectiveness: Multilayer capping is effective in controlling contaminant migration by limiting the infiltration of water and subsequently the leaching of soil-bound contaminants into groundwater, as well as minimizing water and wind erosion. Capping will also minimize direct contact with contaminated surface soil, thus reducing dermal, ingestion, and direct radiation exposures. Capping will reduce the migration of contaminants from the soil to perched groundwater and the Great Miami Aquifer by reducing the amount of infiltration. The COCs present in soil which are predicated to impact groundwater include radionuclides such as uranium, neptunium, strontium, and technetium; organics such as methylene chloride and tetrachloroethene; and inorganics such as mercury and arsenic. The migration of these contaminants would be effectively reduced by a multilayer cap. The process does not provide for reductions in toxicity, mobility, or volume of contaminants, but does reduce the potential for contaminant migration through decreasing infiltration into the soil column. During remedial activities, fugitive emissions would have to be controlled by using dust suppressants and proper personal protective equipment (PPE) to minimize effects on human health and the environment. Multilayer capping is a proven and reliable process which would ensure the long- term isolation of contaminants. Inspection of the capping system and some continued maintenance may be necessary to ensure long-term effectiveness and the ability of the cap to meet the required 1000-year design life.

- Implementability: Materials, equipment, and skilled personnel required for the installation of a multilayer cap are readily available. Some earthwork may be required to achieve proper slopes for surface water runoff control. Because the top of a completed cap would be approximately four feet above current ground elevation, interferences with existing structures may present a problem. This process option could be used in conjunction with deed restrictions and/or continued federal ownership in order to limit the future usage or intrusion of the capped areas.

- Cost: The capital cost for multilayer cap construction is expected to be moderate. The capital costs include materials and installation and are dependent on the extent of the area to be covered. O&M costs, including repairs and periodic inspections, are expected to be low.

Multilayer caps used in conjunction with other processes could attain remedial action objectives and comply with ARARs. The process option would significantly reduce the potential for migration of contaminants to the groundwater through reduction in amounts of leachate generated and through erosion control. Therefore, multilayer capping will be retained as a primary representative process option for incorporation into remedial action alternatives. It will also minimize direct contact with contaminated soil and resultant exposures through dermal ingestion and direct radiation exposures.

M.4.3.2 Subsurface Water Control Technologies

Process options evaluated under the subsurface water control technology include:

- Vertical slurry walls
- Horizontal slurry barrier
- Subsurface drains
- Sheet piling
- Pumping wells.

Vertical Slurry Walls

Vertical slurry walls are low-permeability barriers that restrict horizontal movement of contaminants below the ground surface. Slurry walls could be used to restrict the horizontal movement of perched groundwater or leachate from a contaminant source. Vertical slurry walls could be used in conjunction with other containment options such as caps and horizontal barriers to control leachate generation or to isolate various perched groundwater pockets at the FEMP site. Slurry walls can be constructed by excavating a narrow trench and backfilling with a low hydraulic conductivity material or by "jetting" a soil- or cement-bentonite mixture into the soil.

- Effectiveness: Vertical slurry walls are a proven and reliable process for temporary localized containment of contamination. Vertical slurry walls would be used to reduce the lateral migration of the COCs within the perched groundwater. A slurry wall would be effective in reducing the lateral migration of inorganics such as cadmium, cyanide, lead, and manganese, and organics such as trichloroethene, tetrachloroethene, and methylene chloride. Organics at the FEMP site are sufficiently low in concentration that compatibility with the grouting material should not be a problem. Migration of radionuclides such as uranium, technetium, and neptunium should also be reduced; however, long-term effectiveness concerning the reduction of contaminant migration is unknown. Monitoring would be required to verify effectiveness over the long term. There would be minimal impacts to human health and the environment during the installation of a vertical slurry wall. The process option does not provide reductions in toxicity, mobility or volume of contaminants, but it does reduce the potential for the migration of the contaminants by impeding groundwater movement. This process should be used with capping, or capping and a horizontal barrier, to be more effective and reliable.

- Implementability: Construction of vertical slurry walls is relatively simple, and materials and equipment are readily available. At depths from 75 to 150 feet, installation becomes more difficult and therefore more costly. However, depths of perched water zones at the FEMP site are not expected to exceed 35 to 40 feet.

- Cost: The capital cost for construction of a vertical slurry wall is estimated to be moderate for the expected depth of about 35 feet required for many of the FEMP perched groundwater zones. Capital cost includes materials and construction and backfilling of the slurry wall trench, and is dependent on the depth and the linear

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footage required. O&M costs, which should be limited to monitoring of the performance of the wall and making periodic repairs, are expected to be low.

Vertical slurry walls will be retained as a support option in the formation of alternatives, to be used in conjunction with other process options such as caps in order to control leachate generation or to isolate various perched groundwater pockets.

Horizontal Slurry Barrier

Horizontal slurry barriers are used to restrict vertical flow of groundwater and thus isolate subsurface soil contamination. Horizontal barriers are formed by pumping a slurry made up of a soil or cement, bentonite, and water mixture into notched injection holes enabling the formation of a barrier beneath an area of contamination. In order to form a horizontal layer beneath an area of contamination, injection holes must be drilled either directionally from the site perimeter or down through the contaminated area along a predetermined grid pattern. This bottom barrier, used in conjunction with vertical slurry walls and a cap, can effectively isolate an area of contamination. Due to the depth limitations for this process option, it could only be used to isolate perched groundwater zones at the FEMP site.

- Effectiveness: A horizontal slurry barrier would reduce the migration of contaminants from the soil to the perched groundwater and the Great Miami Aquifer by reducing the amount of infiltration. The COCs present in soil which are predicted to impact groundwater include radionuclides such as uranium, neptunium, strontium and technetium; organics such as methylene chloride and tetrachloroethene; and inorganics such as mercury and arsenic. Organics at the FEMP site are sufficiently low in concentration that compatibility with the grouting material should not be a problem. The migration of these contaminants would be reduced if the barrier is installed properly. Installation would have to be conducted so as to form a continuous barrier to prevent preferential migration pathways. Horizontal slurry barriers are difficult to monitor with respect to their reliability. There would be minimal impacts to human health and the environment during the installation of a horizontal slurry barrier. The process would not provide reductions in toxicity, mobility, or volume of contaminants, but it does reduce the potential for migration of these constituents. This process should be used with capping, or capping and a vertical barrier to be more effective.

- Implementability: Construction of horizontal slurry barriers is relatively difficult, as it involves specialized techniques and equipment.

- Cost: The capital cost for construction of a horizontal slurry barrier is estimated to be high for the FEMP perched groundwater zones. It includes mobilization of specialized equipment, slurry injection into predrilled holes, and would be dependent upon depth and the area of the barrier. O&M costs, which should be limited to periodic repairs and monitoring of the performance of the barrier, are expected to be low.

Horizontal slurry barriers will be eliminated from further consideration as a process option to address groundwater contamination due to questionable reliability and difficulty in construction.

Subsurface Drains

Subsurface drains include any type of buried conduit used to collect, convey, or divert water or leachate by gravity flow. A subsurface drainage system often uses perforated drain pipe or a gravel bed to convey flow to a storage tank or sump for further processing. Due to the depth limitations of subsurface drains, this process option would only be applicable to perched groundwater at the FEMP site.

- Effectiveness: Subsurface drainage systems can be effective in the collection and containment of contaminated subsurface water; however, for full effectiveness, the drains should be designed before the placement of waste at a site rather than afterwards, as is the case at the FEMP site. Subsurface drains do not provide reductions in toxicity, mobility, or volume of contaminants. They reduce but do not eliminate the potential for vertical migration of these constituents. Short-term fugitive dust emissions would be of some concern to construction workers during the trenching operations.

- Implementability: Construction of drains beneath a contaminated soil area can be somewhat difficult, but achievable. Limitations on depth exist. The materials and equipment are readily available. Collected leachate may require treatment before discharge to the local surface stream.

- Cost: Capital costs would be low to moderate and O&M costs would be low. Capital costs would include the installation of conduits, pumps, and any collection tanks or sumps. O&M costs would involve mostly pump maintenance and monitoring costs.

Subsurface drainage systems are usually not as effective as other process options, especially for the control of groundwater flow through vertical migration. This process option will be eliminated from further consideration.

Sheet Piling

The construction of sheet piling involves driving interlocking piles into the ground with a pneumatic or steam-driven pile driver. In some cases the piles are pushed into predug trenches. Lengths of the piles are commonly in the 4 to 40 foot range. Sheet piling can be used to control leachate generation where wastes are deposited in contact with a permanent or seasonal water table.

- Effectiveness: Sheet pilings would not be effective in controlling short term leachate migration. When first placed into the ground, sheet piling cutoffs are very permeable, as the loose edge interlocks allow for easy passage of water. With time, fine soil is washed into the seams resulting in a reduction of water flow. However, the time required for this sealing depends upon the nature of the soil and the flow of water through the wall seams. The wall may never seal tightly because the vertical barrier to

control leachate migration will be installed above the water table. This would produce minimal flow of water through the void spaces of the piling causing the primary COCs in the groundwater, such as uranium, to continue to migrate. Also, sheet pilings are prone to corrosion over the long term.

- Implementability: Sheet pilings can be installed from the surface by using a pile driver. Materials, equipment and labor are readily available.

- Cost: Both capital costs and O&M costs for sheet piling would be low. Capital costs include materials and installation and would be dependent on the length and depth of piling required. O&M costs would be negligible.

Sheet piling will be eliminated from further consideration due to questionable effectiveness.

Pumping Wells

Pumping wells are a series of wells, completed in overburden deposits, used to capture contaminated water in order to contain or reduce a groundwater contamination plume. The wells may either extract or inject water to achieve the objective. Pumping wells could be applicable to the Great Miami Aquifer groundwater at the FEMP site. One or more recovery systems, each consisting of several pumping wells, could be configured to accomplish the reduction and/or containment of contamination plumes within the Great Miami Aquifer.

Several modeling studies (see Appendix F.7.0) were performed at the FEMP site to preliminarily site and size groundwater remediation systems in the Great Miami Aquifer using the Sandia Waste Isolation Flow and Transport (SWIFT) model. The results of the modeling studies indicated that the optimum restoration of on- and off-property groundwater to 20 ppb uranium concentration in the Great Miami Aquifer could be accomplished twice as fast as the optimum on-property containment scenario. The on-property containment scenario provides for establishing a hydraulic barrier at the FEMP property boundary to prohibit off-property migration of on-property Great Miami Aquifer contaminants, at the same time that the off-property Great Miami Aquifer is restored to 20 ppb uranium concentration. The SWIFT model indicated that the optimum total restoration scenario to 20 ppb uranium would meet stated cleanup goals within 30 years while the containment scenario to 20 ppb uranium could require over 100 years to meet stated cleanup levels.

- Effectiveness: Pumping wells are a proven and reliable process for containment of groundwater contamination. All of the COCs present in the groundwater could be effectively extracted and contained with the pumping wells. A number of wells, which could be used for this application, currently exist in the South Plume at the FEMP site. There would be minimal impacts to human health and the environment during the installation of required pumping wells. This option does not address reduction in toxicity or mobility of contaminants, but it does reduce the contaminant volume and potential for migration through containment. Containment by pumping wells is effective

in diverting contamination away from receptor wells, but would have to be used in conjunction with treatment/disposal technologies to achieve remedial goals, which would require a longer time to achieve than the corresponding removal/restoration options.

- Implementability: Construction of pumping wells is relatively simple, and materials and equipment are readily available. Discharge monitoring, and potentially a state NPDES permit, may be required before implementing the pumping well system for Great Miami Aquifer.

- Cost: For pumping wells, capital and O&M costs would be low to moderate. Capital costs would include the installation of additional wells, pumps, and monitoring equipment as required. O&M costs would include electricity and maintenance of wells, pumps, instrumentation, and other equipment.

A series of pumping wells could be used as a containment system for contaminated groundwater in the Great Miami Aquifer; however, it would require a much greater amount of time to reach remedial goals than corresponding removal/restoration systems. Therefore, this process option will not be retained for incorporation into remedial action alternatives.

M.4.4 REMOVAL

The only technology considered for removal is subsurface water extraction.

M.4.4.1 Subsurface Water Extraction Technologies

Process options evaluated under the subsurface water extraction technology include:

- Vertical extraction wells
- Directional extraction wells
- Collection trench/French drain
- Excavation
- Electroosmosis.

Vertical Extraction Wells

Vertical extraction wells are a series of wells, completed in overburden deposits, used to capture contaminated water in order to contain and remove a groundwater contamination plume. These wells are designed and located to provide optimum efficiency in capturing contaminated water while minimizing the collection of uncontaminated water. Vertical extraction wells would be applicable to both Great Miami Aquifer and perched groundwater at the FEMP site. As previously discussed in Section 1.0 of this FS, an extraction well system is presently operating at the leading edge of the South Plume. This system has been designed to provide sufficient capacity for the installation of additional recovery wells. Recovered water is directed to the FEMP site for treatment through a single discharge line.

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- Effectiveness: Vertical extraction wells are a proven and reliable process for removal of contaminated groundwater. The COCs present in the groundwater would be effectively removed using vertical extraction wells. Many wells, which could possibly be used for this application, currently exist in and around the FEMP site. There would be minimal impacts to human health and the environment during the installation of additionally required extraction wells. Modeling studies indicate that a time frame of 30 years would be required to meet remedial goals using vertical extraction wells in multiple groundwater recovery systems for the purpose of remediating the Great Miami Aquifer. Vertical extraction wells would be more effective in removing contaminated groundwater from the Great Miami Aquifer than from the perched groundwater zones, which would have slower recharge rates. Modeling results (see Appendix F.6.0) indicate that more than 3000 wells would be required to reduce uranium concentrations below 20 ppb in the perched zones within a 35 year time frame.

- Implementability: Construction of vertical extraction wells is relatively simple, and materials and equipment are readily available. Additional easements will likely be required before extending the extraction well system and discharge line, if required, for off-property areas.

- Cost: For vertical extraction wells, capital and O&M costs would be moderate for Great Miami Aquifer groundwater removal and relatively low for perched groundwater removal. Capital costs would include the installation of additional wells, pumps, conveyance lines, piezometers, and monitoring equipment as required. O&M costs would include electricity and maintenance of wells, pumps, instrumentation, groundwater monitoring and monitoring of piezometers (drawdown).

Vertical extraction wells could be used to effectively remove contaminated Great Miami Aquifer groundwater. Therefore, this process will be retained for incorporation into remedial action alternatives as the representative option for subsurface water extraction technologies for Great Miami Aquifer groundwater.

A variation of extraction well operation called pulse pumping involves the cycling of well pumps on and off in active and resting phases. Pulse pumping could eliminate the later stage decline in contaminant loads discharged by extraction wells under a steady state operation, and could prevent the formation of stagnation zones associated with the continuous pumping of wells. This may be an applicable technique to be used in conjunction with extraction wells to remove maximum contaminant concentrations in the Great Miami Aquifer with the minimum volume of extraction required. Pulse pumping will be retained as a potential variation of the extraction well operation as a method of reducing the time required for remediation.

Due to the heterogeneity of the glacial overburden and the hydrogeologic properties of the perched zones, a range of process options are potentially necessary to address the removal of contaminated groundwater in the perched zones. Although vertical extraction wells could not realistically restore

the entire perched groundwater zone in a timely manner, they are considered a feasible process which could be applied under certain conditions to the various perched water zones. Therefore, this process option is being retained in tandem with other viable extraction options as a potential support process for addressing perched water.

Directional Extraction Wells

Directional extraction wells are basically the same as vertical extraction wells except that they are directionally rather than vertically drilled. The major advantage is that they can pump from a greater area than vertical wells and, therefore, would require a smaller number of wells to be installed for the same application. This option would apply to Great Miami Aquifer groundwater and could also be applied to perched groundwater zones.

- Effectiveness: Directional extraction wells are a proven and reliable process for removing contaminated water. There would be minimal impacts to human health and the environment during the installation of directional extraction wells. They are effective in diverting contamination away from receptor wells, but would have to be used in conjunction with treatment/disposal technologies to achieve remedial goals.

- Implementability: Construction of directional wells is more difficult than the construction of vertical wells, but this process has proven to be very effective in similar applications.

- Cost: For directional extraction wells, capital and O&M costs would be more expensive than for vertical extraction wells. Capital costs would include the installation of additional wells, pumps, and monitoring equipment as required. O&M costs would include electricity and maintenance of wells, pumps, instrumentation, and other equipment.

The main advantage of directional extraction wells over vertical wells is that normally fewer would have to be installed to draw from the identical groundwater area. This advantage is somewhat negated by the fact that many vertical extraction wells, already in place in the groundwater zones, could potentially be used for this application. Therefore, directional extraction wells will be eliminated from further consideration as a potential subsurface water extraction process option.

Collection Trench/French Drain

Collection trenches/French drains are trenches or buried conduits used for removal of water by gravity flow. This application is limited to relatively shallow depths, but could be applied to certain perched water zones at the FEMP site.

- Effectiveness: The collection trench/French drain option is a proven and reliable process. All the COCs present in the groundwater would be effectively removed using collection trenches and/or French drains. However, reliability of collection trenches

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falls off considerably at depths approaching 40 feet due to the difficulty of shoring during installation. This could present a problem at the FEMP site where it is anticipated that trenching depth requirements would vary between 20 to 40 feet, depending on the perched zone area under consideration. In addition, modeling studies indicate that up to 58,000 linear feet of trenches would have to be placed throughout the entire perched groundwater zone for effective remediation to less than 20 ppb uranium within the 35-year desired time frame. Also, short-term fugitive dust emissions would be of some concern to workers during the construction period.

- Implementability: Materials and equipment for this process option are readily available; however, skilled labor would be required as trenching depths approach 40 feet. The existence of tanks, buildings, or underground utilities tend to complicate the installation process.

- Cost: The capital costs associated with the construction and installation of collection trenches and associated collection sumps are expected to be moderate. O&M costs, which would include periodic inspections and maintenance, are expected to be low.

Although this process option could not effectively remediate the entire perched groundwater zone in a timely manner, it may have limited applicability to certain shallow perched groundwater pockets where recharge rates are sufficiently high and no significant structures or underground utilities would interfere with the excavation procedure. The collection trench/French drain will be retained as a possible support option applicable to certain shallow pockets of perched groundwater at the FEMP site.

Excavation

Excavation/dewatering involves the large scale removal of soil using traditional equipment such as backhoes, hydraulic excavators, bulldozers and front-end loaders, as appropriate, and the dewatering of the excavations by sump pumps to remove contaminated groundwater. At the FEMP site, this could be applicable to shallow perched water zones where the overburden containing contaminated groundwater can be excavated. This removal technique would be especially useful in those cases where excavation is also used to remove contaminated soil located above or adjacent to the saturated overburden.

- Effectiveness: Excavation/dewatering is a proven and reliable process for removal of contaminated subsurface soil and groundwater. The process option would be effective in removing select saturated glacial deposits with contaminated perched groundwater. All the COCs present in the perched groundwater would be removed using excavation and dewatering. Short-term fugitive dust emissions would be of some concern to workers during the excavation process. These risks could be reduced substantially by the use of PPE and dust suppressants.

- Implementability: The equipment necessary to perform excavation and dewatering of saturated overburden in the contaminated perched zones at the FEMP site is

conventional and readily available. This procedure becomes more difficult as depths of contamination approach 40 feet; however, the depth of contaminated pockets of perched groundwater at the site are in the range of 25 to 40 feet. The general nature of the saturated overburden is such that dewatering should not be required before the excavation process. Excavation of soil beneath a building or structure may require bracing and/or shoring before implementation.

- Cost: For excavation and dewatering, capital costs would be low and O&M costs would be negligible. Capital costs, which include skilled labor and equipment, would increase if buildings and/or other structures were located above or adjacent to the excavated overburden.

Removal of contaminated water from perched zones by excavation and dewatering is a highly effective and implementable technique. Excavation will be retained for incorporation into remedial alternatives as a representative primary process option in conjunction with other identified perched water extraction options. As previously stated, a range of available process options must be maintained through the alternative development process to address the variable geologic conditions associated with the glacial till for the removal of perched groundwater.

Electroosmosis

Electroosmosis is a technique used for dewatering soil that contains significant concentrations of ionized metals and inorganic contaminants. In this process an electrical field is applied to the soil or overburden to induce flow in a certain direction. Due to area limitations on this technology, it could only apply to shallow perched groundwater zones at the FEMP site.

- Effectiveness: Electroosmosis is a proven process used to dewater soil; however, it has seen very limited application at hazardous waste sites. Inorganic COCs present in the perched groundwater may be effectively removed using electroosmosis. (Treatability studies would be required to determine its effectiveness on specific COCs). The basic chemical reaction in electroosmosis causes the electrolysis of water which then leads to the formation of hydrogen gas. This reduction in hydrogen ion concentration in the saturated soil can increase the soil pH to 13 or greater. In addition, precipitation of salts and secondary minerals could decrease the effectiveness of this technology. Finally, any nonionic contaminants would remain in place.

- Implementability: Materials and equipment for this process option are readily available; however, skilled labor would be required for implementation. The existence of tanks, buildings, or underground utilities tends to complicate the installation process.

- Cost: The capital costs associated with the installation of an electroosmosis system and associated collection sumps are expected to be moderate. O&M costs, which would include periodic inspections and maintenance and possible excessive electrical costs, are expected to be high.

There are several effectiveness and implementability concerns about electroosmosis. Therefore, it will be eliminated from further consideration as a removal process option for perched groundwater.

M.4.5 TREATMENT

The technologies considered for treatment include in situ treatment, physical treatment, chemical treatment, physical/chemical treatment and biological treatment.

M.4.5.1 In Situ Treatment Technologies

The only process option evaluated under the in situ treatment technology is vapor sparging.

Vapor Sparging

Vapor sparging could be applied to the Great Miami Aquifer as a support process option used to enhance the effectiveness of groundwater extraction technologies by increasing the solubility/mobility of uranium through oxidation to the hexavalent state, preferably in the carbonate form. Sparging with air or CO_2 could increase the mobility of uranium in a carbonate-rich groundwater matrix and should be an acceptable process option for the Great Miami Aquifer.

- Effectiveness: Vapor sparging, using air or CO_2, is a proven and reliable in situ process typically used to remove and enhance degradation of VOCs in unsaturated soil, but more recently has also been used as an oxidizer to assist in desorbing certain metals from soil. This process could increase the mobility of uranium depending upon the amount of carbonates present in the groundwater, and therefore speed up contaminant plume remediation efforts in a pump and treat scenario. The reliability of vapor sparging decreases at greater depths.

- Implementability: Materials, equipment, and labor for this process option are readily available as the air or CO_2 could be injected into the groundwater using a series of injection wells. Due to the sole-source drinking water status of the aquifer, obtaining the necessary regulatory approvals to perform sparging may be difficult.

- Cost: The capital and O&M costs associated with air sparging are expected to be moderate to high, depending on whether air or CO_2 is used. Capital costs would include a system of injection fans, ducts, additional injection wells, and CO_2 storage tanks, if necessary. O&M costs would include equipment maintenance, electricity, periodic groundwater monitoring, and bulk liquid CO_2, if necessary.

Vapor sparging has some questionable effectiveness and implementability concerns. Therefore, it will be eliminated as a representative process option in the formation of remedial alternatives; however, it may be used as a support option in conjunction with extraction and treatment techniques to decrease the time required for aquifer restoration by increasing the mobility of COCs such as uranium.

M.4.5.2 Physical Treatment Technologies

Process options evaluated under the physical treatment technology include:

- Equalization
- Sedimentation/Clarification
- Ultrafiltration
- Multimedia filtration
- Reverse osmosis
- Volatilization
- Adsorption.

Equalization

Equalization, in the form of a holding tank or basin at the treatment plant inlet, allows for dampening of flow fluctuations and reduction of variations in chemical composition of the influent. This process option promotes a constant discharge rate and near-constant water quality to prevent flow surges or upset conditions that could affect downstream processes. Equalization could be applicable to all groundwater, process wastewater and collected storm water at the FEMP site.

- Effectiveness: Although equalization would not directly remove or treat inorganic, organic, and radionuclide COCs, it is a proven and reliable process that may be a necessary part of any treatment scheme at the site. Removal systems for both Great Miami Aquifer and perched groundwater will result in contaminated water of varying chemical composition and flow rates being received for treatment. Flow and chemical equalization may be required to dampen flow and COC concentration surges for select wastewater and groundwater streams to ensure the proper operation of downstream equipment.

- Implementability: Equalization is readily implementable and could use existing facilities available at the FEMP site.

- Cost: Capital costs and O&M costs are expected to be low. Capital costs include the installation of tanks or sumps and mixers. O&M costs would include equipment maintenance and electricity.

Equalization would be effective in dampening flow and contaminant concentration surges and would be easily implementable. Therefore, this process has been retained as a support option for use in conjunction with other treatment process options in the formation of alternatives.

Sedimentation/Clarification

Sedimentation/clarification is a process that removes the suspended solids from a liquid by producing quiescent hydraulic conditions, thus allowing the forces of gravity to settle out the settleable solids from suspension. This technology may be used as a support option in conjunction with precipitation.

Sedimentation/clarification would apply to inorganic COCs in the perched and Great Miami Aquifer groundwater.

- Effectiveness: Sedimentation/clarification is a proven and reliable process which, when used by itself, will not reduce wastewater contaminant concentrations to sufficient levels to permit discharge. If precipitation is selected for the removal of radionuclide and inorganic COCs, a clarifier/thickener would be used to collect and concentrate the precipitated solids before dewatering. No apparent short-term impact to human health and the environment would occur upon implementation of this option.

- Implementability: Sedimentation/clarification is readily implementable and frequently designed into treatment systems as a part of the treatment scheme. Sludge would require dewatering before off- or on-property disposal.

- Cost: Capital costs are expected to be moderate and O&M costs are expected to be low. Capital costs include the installation of the clarifier/thickener system. O&M costs would include electricity, maintenance of pumps and scraper mechanisms, and sludge handling/disposal.

The process option of sedimentation/clarification has been retained as an inorganic treatment support option, to be used in conjunction with precipitation, in the formation of alternatives for all groundwater, process wastewater, and storm water requiring treatment before discharge.

Ultrafiltration

Ultrafiltration could be applicable for the removal of fine suspended or colloidal inorganic COC particles, or any high molecular weight soluble organic COCs which are found in the perched groundwater, the contaminant plumes of the Great Miami Aquifer, process wastewater, or storm water.

- Effectiveness: Ultrafiltration is an emerging technology that is undergoing improvement and adaptation to numerous wastewater applications. Although this option could remove high molecular weight organic COCs in the dissolved state, these are not major COCs at the FEMP site, and they could be removed more efficiently by a process such as activated carbon adsorption. Fine suspended solid contaminants could also be removed by conventional filtration processes, which are more reliable. Ultrafiltration could not address the dissolved inorganics and radionuclides which are the major COCs for groundwater. No apparent impact to human health and the environment would occur upon implementation of this option.

- Implementability: Materials and specialized equipment for ultrafiltration are readily available; however, skilled labor would be required for implementation. In addition, residues generated by this treatment process require dewatering before on-property or off-property disposal.

- Cost: Capital costs and O&M costs are expected to be high for ultrafiltration. Capital costs would include bench- and pilot-scale studies of various membrane types and design and construction of the system, while O&M costs would include equipment maintenance, membrane replacement, chemical additions, electricity, dewatering and disposal of sludge, and skilled operators.

Ultrafiltration has several effectiveness concerns and implementability difficulties. Therefore, it will be eliminated from further consideration as a process option for the physical treatment of inorganics.

Multimedia Filtration

Multimedia filtration is a process using a porous medium to remove suspended solids from a liquid. The process could be applicable to all wastewater, storm water, and groundwater at the FEMP site as a pretreatment process to remove suspended solids before other treatment processes and/or for the final polishing of treated effluent. Filtration is especially useful in reducing contaminant levels of particulate metals, radionuclide COCs, and organic COCs that are bound to suspended solid materials.

- Effectiveness: This technology is widely used and reliable for the removal of suspended materials, and it can be staged to remove progressively smaller particles. These types of contaminants may not be easily and/or efficiently removed by other treatment methods such as reverse osmosis, ion exchange, or carbon adsorption, making filtration a common pretreatment step for those treatment processes. However, multimedia filtration is not effective in the removal of dissolved organic, inorganic, and radionuclide COCs, and therefore could not achieve remedial goals by itself. No apparent impact to human health and the environment would occur upon implementation of this option.

- Implementability: Multimedia filtration systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. Filter media will need to be backwashed frequently and occasionally replaced or regenerated, resulting in the generation of sludge for dewatering and disposal.

- Cost: Capital costs for multimedia filtration are low, as are O&M costs. Capital costs would include the filter equipment and the filtration media. O&M costs may elevate somewhat if high turbidity in the pumped groundwater or wastewater requires additional filter maintenance and replacement of media.

Multimedia filtration would be effective in removing suspended matter from all FEMP groundwater, process wastewater, and storm water and would be easily implementable. Therefore, this process has been retained as a support option for use with other treatment processes in the formation of alternatives.

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Reverse Osmosis

Reverse osmosis, which could be applied to all FEMP groundwater, uses a semipermeable barrier to remove most dissolved COCs. The membrane is permeable to water but impermeable to most dissolved substances, both organic and inorganic. Reverse osmosis systems are operationally sensitive. Therefore, close monitoring of the temperature, pressure, and pH of the contaminated solution is necessary. In addition, the chemical and physical structure of the membrane must be closely monitored because the contaminants in the solution may react with it and reduce its integrity.

- Effectiveness: Reverse osmosis is a commonly used and reliable process which reduces excess dissolved solids, removes many organics and metals, and produces almost turbidity-free water. It would be effective in removing many organic (nonhalogenated) and inorganic COCs. However, reverse osmosis is not as effective as ion exchange for the removal of low-level uranium contamination. Before treatment by this process, the wastewater should be pretreated to: adjust pH to within a range of 4.0 to 7.0, remove suspended materials which may plug the membrane, and remove certain organic COCs, such as dichloroethane, methylene chloride, trichloroethene and tetrachloroethene, which may degrade the reverse osmosis unit membranes.

- Implementability: Although equipment and resources are specialized, the reverse osmosis process is commercially available. Reverse osmosis membranes, in general, are subject to deterioration and may require frequent replacement. Pretreatment will be required to optimize pH and remove substances that may foul or degrade the membranes. A sizeable reject stream, which could be as much as 25 percent of the feed stream flow rate, must be dewatered and disposed of at an on- or off-property facility.

- Cost: Capital and O&M costs for reverse osmosis are high. Capital costs include pilot studies and design and construction of the system. The primary O&M costs would include membrane replacement, chemical additions, electricity, residual handling, and skilled operators.

In conjunction with the proper pretreatment, reverse osmosis may be a viable process for the removal of uranium and other dissolved contamination in Great Miami Aquifer and perched groundwater, storm water, and process wastewater at the FEMP site. However, because of effectiveness and implementability concerns, and relatively high O&M and capital costs, reverse osmosis has been eliminated from further consideration.

Volatilization

Volatilization, or air stripping, could be applicable to all FEMP groundwater for the removal of volatile organic COCs. This aeration process encourages the transfer of VOCs from the aqueous phase to the gas phase as defined by Henry's Law. Removal efficiencies of VOCs typically exceed 99 percent depending on the operating parameters as well as the physical properties of the organic contaminant(s). This process does not remove the nonvolatile COCs. The countercurrent packed tower is the most commonly used air stripping configuration. Steam stripping is very similar to air

stripping, except that steam is used as a carrier gas and provides heat to enhance removal. Steam stripping is generally considered for product recovery and/or for removal of organic compounds that are only slightly more volatile than water.

- Effectiveness: Air stripping is a well proven and reliable technology that would be effective for removing the volatile COCs such as dichloroethane, methylene chloride, trichloroethene and tetrachloroethene from groundwater at the FEMP site. Because air stripping only transfers the volatile contaminants from water to the air, the off-gas may have to be treated by other means such as granular activated carbon adsorption, catalytic oxidation, or thermal destruction. For contaminants at the FEMP, steam stripping does not provide any advantage in effectiveness beyond that of air stripping.

- Implementability: Air stripping would be readily implementable at the site. There are a significant number of vendors that provide air stripping technology. In order to meet air emission requirements, control of off-gas emissions may be required. A maintenance problem associated with air stripping is the channeling of flow resulting from clogging in the packing material. The presence of suspended solids, iron, and slightly soluble salts such as calcium carbonate in the groundwater could present a clogging concern, unless these materials are removed prior to air stripping. An air emissions permit would be required.

- Cost: The capital costs are moderate and include installation of the system and the cost of packing material. O&M costs range from low to moderate depending on influent contaminant concentrations, the degree of organic removal, and the type of off-gas treatment required.

Air stripping, using a countercurrent packed tower, is an effective and reliable technology for VOC removal; however, volatile COCs are a very small part of the total contamination present in FEMP groundwater. Metals, including uranium contamination, must be addressed by other treatment processes. VOCs can be more efficiently removed from groundwater (along with the other nonvolatile organic contaminants) by aqueous phase activated carbon adsorption. Therefore, volatilization will be eliminated from further consideration as a physical treatment process option.

Adsorption

Activated carbon adsorption, which would be applicable to all FEMP groundwater, storm water, and process wastewater, is a common technology used for the removal of organic contaminants from water. Activated carbon will adsorb many organic compounds to some extent, but is most effective for the more polar and less soluble compounds. The fundamental principle behind activated carbon treatment involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of the specially treated (activated) carbon grains. As water is filtered through the adsorbent, the organic molecules eventually occupy all of the surface sites on the carbon grains. The exhausted carbon must then be either regenerated or disposed of according to federal and state

regulations. Typical activated carbon adsorption treatment systems include gravity flow or pressure flow columns in series and/or parallel configuration with backwashing capability.

- Effectiveness: Activated carbon adsorption is a well proven, reliable technology that would be effective for removing the soluble organic COCs such as dichloroethane, dichloroethene, methylene chloride, trichloroethene and tetrachloroethene from the FEMP site groundwater. It can also remove certain heavy metals, especially those in complexed form. The low organic COC concentrations in the groundwater provide the ideal application for carbon adsorption resulting in a relatively low carbon consumption. No apparent impact to the environment would occur upon implementation of this option; however, a potential risk to human health from the disposal and handling of spent carbon exists.

- Implementability: This process option would be readily implementable as there are a sufficient number of vendors that provide carbon adsorption units. Pretreatment may be required to remove suspended solids concentrations above 50 mg/L, or calcium or magnesium concentrations above 500 mg/L to prevent clogging and high pressure drops across the carbon beds. Spent carbon containing the concentrated organic contaminants would have to be disposed of at an off-site or on-property disposal facility. Regeneration of the activated carbon would not be practical because some radioactive contaminants would be adsorbed with the organics, thus making the spent activated carbon unacceptable for reuse. Special handling of the periodically generated backwash liquids must also be taken into account.

- Cost: Capital costs and O&M costs for carbon adsorption are moderate. Capital costs would include activated carbon cost plus design and installation of the system. O&M costs may vary depending on the carbon usage rate, which is a function of influent contaminant concentrations.

Carbon adsorption is a viable process option for treating soluble organic COCs in Great Miami Aquifer and perched groundwater, process wastewater, and storm water at the FEMP site. In the development of alternatives, carbon adsorption has been retained as the representative primary process option for treatment of organic contaminants in the Great Miami Aquifer groundwater. Other process options will be required to address the inorganic and radionuclide contaminants.

M.4.5.3 Chemical Treatment Technologies

Process options evaluated under the chemical treatment technology include the following:

- Ion exchange
- Electrodialysis reversal
- Coagulation/Flocculation
- Neutralization (pH adjustment)
- Chemical precipitation
- Enhanced oxidation
- Chemical reduction.

Ion Exchange

Ion exchange could be applicable to all FEMP wastewater, storm water, and groundwater as a method to remove inorganic ions, including metals and radionuclides. Ion exchange resins are insoluble polymer beads containing fixed cations or anions capable of reversible exchange with mobile ions of the same charge in solutions with which they are brought into contact. The ion exchange resins will eventually be exhausted and must be either disposed of or regenerated. The regeneration waste, which contains high concentrations of contaminants, must be further treated and/or disposed of in accordance with federal and state regulations.

- Effectiveness: Ion exchange is effective for the removal of both soluble metallic cations and anions such as halides, sulfates, and nitrates. Because of resin capacity and regeneration restrictions, ion exchange is most applicable for treating dilute waste streams. This process option could be designed specifically to remove the inorganic COCs such as arsenic, cadmium, lead, manganese, mercury and magnesium, and radionuclide COCs, such as technetium, uranium and strontium. Cyanide could also be removed if it is present in a metallic complex. Before treatment by this process, the groundwater and wastewater should be pretreated to remove suspended materials, which may plug the resin bed, and certain detrimental substances such as aromatic organics, which may decrease the capacity of the resin through irreversible adsorption. No apparent impact to the environment would occur upon implementation of this option; however, a potential risk to human health exists from the disposal and handling of regenerant solutions and spent resin.

- Implementability: Ion exchange would be implementable. There are many vendors that provide ion exchange units. The resins may be used once and disposed of or they may be regenerated. In either case, the exhausted resin must be disposed of at an off-site facility, or stabilized and placed in an on-site disposal facility.

- Cost: Capital costs and O&M costs are moderate for ion exchange. Capital costs include initial resin cost, design, equipment, installation, and sophisticated instrumentation. O&M costs would include replacement resin and/or the cost of regeneration chemicals.

Ion exchange is a viable process for the removal of uranium and other inorganic ionic species from Great Miami Aquifer and perched groundwater, storm water and other wastewater at the FEMP site. Ion exchange has been incorporated into the remedial action alternatives as the representative primary process option for treatment of radionuclide and inorganic ionic COCs from the Great Miami Aquifer groundwater.

Electrodialysis Reversal

Electrodialysis reversal could be applicable to all FEMP groundwater, storm water, and process wastewater for the treatment of inorganics, metals, and radionuclide COCs. This process concentrates or separates ionic species dissolved in an aqueous solution by passing contaminated water

through a cell containing alternately placed cation-permeable and anion-permeable membranes, then applying electrical potential across the membranes as the motive force for ion migration. The ion selective membranes are made up of thin sheets of ion exchange resin reinforced with a synthetic fiber backing.

- Effectiveness: Electrodialysis reversal has been demonstrated to be effective in the recovery of metal salts from plating rinses. It could be applied to separate heavy metal COCs such as arsenic, cadmium, lead, manganese, mercury and magnesium. However, it has been used only on an experimental basis for treatment of radionuclide COCs such as technetium, radium and uranium. Treatability studies would be required to confirm the effectiveness of electrodialysis reversal for radionuclide removal. Before treatment by this process, the wastewater should be pretreated to remove suspended solids or any organic COCs which may foul the membranes. No apparent impact to the environment would occur upon implementation of this option; however, a potential risk to human health exists from the disposal and handling of the brine or concentrated residual waste stream.

- Implementability: Electrodialysis reversal would be implementable, provided that treatability studies could show that it is effective for the treatment of uranium. The concentrated brine must be dewatered and sent to an off-site or on-property facility for disposal.

- Cost: Capital costs and O&M costs are high for electrodialysis reversal. Capital costs include extensive studies, design, equipment, and installation. O&M costs would include membrane replacement, electricity, skilled operators, and brine handling and disposal.

Electrodialysis reversal is potentially applicable; however, it has not yet proven to be reliable in the treatment of uranium as is the case with ion exchange processes. Therefore, electrodialysis reversal will be eliminated from further consideration as a chemical treatment process option.

Coagulation/Flocculation

Small colloidal solid particles are often unable to be effectively removed by sedimentation or filtration. Aggregation of these particles into larger, more settleable/filterable particles is referred to as coagulation/flocculation. Common additives used to accomplish this aggregation include polymers, alum, lime, ferric chloride, and potassium ferrate. All of these reagents have been tested extensively on FEMP groundwater, storm water, and process wastewater. These chemicals act to neutralize surface charges and promote attraction of colloidal particles.

- Effectiveness: Coagulation/flocculation is a well-proven and reliable process option closely associated with filtration and sedimentation/clarification treatment processes. It will allow insoluble metal and radionuclide COCs to be effectively removed from

contaminated groundwater, storm water, and process wastewater. No apparent impact to human health or the environment would occur upon implementation of this option.

- Implementability: Coagulation/flocculation is readily implementable, with many available vendors capable of providing the necessary chemicals.

- Cost: Capital costs and O&M costs are expected to be low for flocculation/ coagulation. Capital costs would include feed tanks, pumps, and mixers. O&M costs include maintenance of equipment, dewatering and disposal of sludge, and chemicals.

Coagulation/flocculation would be effective in aggregating fine solid particles and therefore in aiding the filtration and clarification processes. It would also be implementable and has been retained as a support treatment process applicable to all FEMP groundwater, stormwater, and process wastewater to be used in conjunction with other treatment process options, such as chemical precipitation and clarification, in the formation of remedial alternatives.

Neutralization (pH Adjustment)

Neutralization is a treatment process for adjusting the pH (acidity/alkalinity) of a solution. This is generally accomplished by adding acidic compounds to balance alkaline solutions or vice-versa. This option could be applicable to all FEMP groundwater as either a pretreatment measure to optimize the effectiveness of other treatment processes or as a finishing step before discharge to meet specified water quality criteria.

- Effectiveness: Neutralization is a proven and reliable means of balancing or changing the pH of a solution. The process is best performed in a well-mixed system. A thorough analysis of the wastewater to be treated is advisable to avoid the creation of compounds more toxic than the original compounds and to ensure that incompatible compounds are not introduced into the system. No apparent impacts to human health or the environment, except for workers who would be handling the treatment chemicals, would occur upon implementation of this option.

- Implementability: Neutralization is easily implemented, widely used, and commercially available. Limited construction is necessary to include neutralization equipment as a step in a treatment system.

- Cost: The capital and O&M costs for neutralization are expected to be low. Capital costs would include feed tanks, pumps, and mixers, while O&M costs would include maintenance of equipment and replacement chemicals.

Neutralization has been retained in the formation of alternatives as a support option for use in conjunction with other treatment process options to meet discharge requirements. It is applicable to all FEMP groundwater, process wastewater, and collected storm water.

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Chemical Precipitation

Chemical precipitation involves the addition of a chemical reagent, often an acid or base and usually in conjunction with a coagulant/flocculant aid, to create reactions that cause soluble inorganic contaminants to become insoluble and thus precipitate out of solution. This process option could be applicable to treat heavy metals, uranium, and other radionuclides in the Great Miami Aquifer and perched groundwater, storm water, and process wastewater.

- Effectiveness: Chemical precipitation is a well-proven and reliable process option that would allow insoluble metals and radionuclides to be effectively removed from contaminated groundwater, storm water, and process wastewater. Chemical precipitation could also remove cyanide if it is present in a metallic complex. No apparent impact to human health or the environment, except for workers who would handle the treatment chemicals, would occur upon implementation of this option.

- Implementability: Chemical precipitation is readily implementable, with many available vendors capable of supplying the necessary equipment.

- Cost: Capital costs are expected to be low and O&M costs are expected to be moderate for chemical precipitation. Capital costs would include feed tanks, pumps, and mixers, while O&M costs would include maintenance of equipment, dewatering and handling of sludge, and chemicals.

Chemical precipitation using chemical reagents such as alum, ferric chloride or potassium ferrate in conjunction with pH adjustment would be effective in reducing the solubilities of uranium, heavy metals, and other radionuclides and could be used in conjunction with clarification/sedimentation to meet remedial goals. Chemical precipitation would be implementable and has been retained as a primary process option in the treatment of perched groundwater, process wastewater and collected storm water at the FEMP site. It is anticipated that concentrations of uranium, heavy metals and other radionuclides in the groundwater of the Great Miami Aquifer will not be sufficiently high to support the need for treatment by chemical precipitation.

Enhanced Oxidation

Enhanced oxidation processes typically use a controlled combination of either ozone or hydrogen peroxide and ultraviolet (UV) light to induce photochemical oxidation of organic compounds. This treatment results in the oxidation of organic contaminants at a rate many times faster than that obtained from applying UV light alone. A typical continuous flow system consists of an oxygen or air source, an ozone generator or hydrogen peroxide feed system, an ultraviolet/oxidation reactor, and an ozone decomposer. Flow patterns and configurations are designed to maximize exposure of the contaminated water to the UV radiation, which is supplied by an arrangement of UV lamps. If ozone is used, reactor gases are passed through a catalytic ozone decomposer, which converts remaining

ozone to oxygen and destroys any volatiles. Enhanced oxidation could be applied to all FEMP groundwater, storm water, and process wastewater for the treatment of organic contaminants.

- Effectiveness: Enhanced oxidation can effectively oxidize halogenated organics, benzene derivatives, and various aliphatics. Certain COC alkenes such as dichloroethene and trichloroethene have been reduced from levels of 20,000 ppb to less than 5 ppb. Effectiveness varies greatly depending on the COC. Typically, alkenes would be readily removed, while COC alkanes such as dichloroethane are more difficult to remove. This process is considered an innovative technology as only a few commercial systems have been installed and tested. Bench- and pilot-scale treatability studies would, therefore, need to be conducted to determine the actual effectiveness and cost of applying this process to the contaminants in the groundwater at the FEMP site. Pretreatment of very turbid perched groundwater would be necessary for this process to be effective. No apparent impact to human health or the environment would occur upon implementation of this option.

- Implementability: Enhanced oxidation should be implementable. Only a few vendors, however, currently offer this technology. Recent improvements have been made by hydrogen peroxide/UV vendors to minimize energy usage and reduce UV lamp fouling problems. With this treatment, no toxic materials are emitted to the atmosphere or adsorbed onto media that require further treatment or disposal. Hydrogen peroxide is a strong oxidizing agent; therefore, containment and other engineering controls are required to minimize potential risks associated with peroxide releases.

- Cost: Capital costs are high and O&M costs are moderate to high for enhanced oxidation. Capital costs include extensive studies, design, equipment and installation of the system. Operating costs vary significantly depending on flow rate and contaminant type and concentration. Enhanced oxidation requires high energy usage, which can result in prohibitive costs.

Enhanced oxidation is effective in removing some organic COCs. However, organics are not the major COCs at the FEMP site, and because this innovative technology does not have the reliability record of other organic treatment processes, it will be eliminated from further consideration as a chemical treatment process option.

Chemical Reduction

Chemical reduction consists of the use of strong reducing agents, such as sulfur dioxide, sulfite, or ferrous iron, to chemically lower the oxidation state of inorganic contaminants present in wastewater. A few proprietary one-step processes are conducted at neutral pH using ferrous iron compounds to eliminate the conventional pH reduction step associated with this process. Chemical reduction could apply to all FEMP groundwater, stormwater, and process wastewater that may contain hexavalent chromium as one of the inorganic COCs.

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- Effectiveness: Chemical reduction of hexavalent chromium to the trivalent form is a well-proven process. However, most operational historical data available concerns process wastewater at much higher influent concentrations than anticipated for any of the expected contaminated water at the FEMP site. Typically, for hexavalent chromium reduction, the waste stream is first lowered to a pH between 2 and 3 using sulfuric acid, then a reducing agent such as sulfur dioxide is added. Ferrous compounds such as ferrous sulfate or ferrous chloride can also be used effectively as reducing agents, which simultaneously precipitate the chromium. No apparent impact to the environment would occur upon implementation of this option; however, a potential risk to human health exists for workers who would be handling the treatment chemicals.

- Implementability: Chemical reduction would be readily implementable; however, only a few vendors are available for the proprietary processes which simultaneously precipitate the metals. Sludge generated must be dewatered and sent to an on-property or off-site facility for disposal.

- Cost: Capital costs are expected to be moderate and O&M costs are expected to be low to moderate for the reduction process. Capital costs include feed tanks, pumps and mixers, plus installation of the system. Sulfur dioxide, ferrous sulfate, and ferrous chloride are primarily used as reducing agents because they are relatively inexpensive and effective.

Chemical reduction is effective in treating water containing hexavalent chromium as one of the inorganic COCs. However, its concentration in FEMP process wastewater, groundwater, and storm water is expected to be too low for the effective use of this process option. Therefore, chemical reduction will be eliminated from further consideration as a chemical treatment process option for use in the formation of alternatives.

M.4.5.4 Physical/Chemical Treatment Technologies

The only process option evaluated under the physical/chemical treatment technologies is treatment by the AWWT facility.

Treatment By AWWT Facility

The AWWT facility, located at the FEMP site, is currently under construction and scheduled to become operational in January 1995. This system is designed to treat process wastewater, surface water, and contaminated perched groundwater generated at the FEMP site during remedial operations. Phase I and Phase II of the facility consist of two treatment trains, each containing identical support and primary treatment process options and operating in parallel. The treatment processes include: equalization, pH adjustment (1st stage), chemical precipitation (using potassium ferrate, alum or ferric chloride), clarification, multimedia filtration, carbon adsorption, pH adjustment (2nd stage), ion exchange, neutralization, and final filtration. The two parallel systems are combined just before discharge for the final neutralization and filtration steps.

The AWWT Phase I has a design flow rate of 700 gpm and is designed to treat storm water runoff from the storm water retention basin, flows discharged by the storm sewer lift station, and projected volumes from the storm sewer improvement project. This design flow rate is approximately twice the expected storm water flow rate in order to handle flow surges and anticipated treatment plant downtime.

The AWWT Phase II has a design flow rate of 400 gpm in order to treat baseline site wastewater which includes effluents from the general sump, biodenitrification treatment plant, and sewage treatment plant, storm water collected from the former production area and the waste pit perimeter, and future remedial streams such as contaminated perched groundwater and wastewater generated from Operable Unit 5 remedial actions.

The design basis for the AWWT Phases I and II does not include the treatment of contaminated groundwater from any Great Miami Aquifer extraction systems. However, as part of the EPA-mandated supplemental environmental project, the AWWT Phase I system can be used on an interim basis to treat an average of 350 gpm of Great Miami Aquifer groundwater from Operable Units 1 through 5 when no storm water is available. In addition, approximately 200 gpm of Great Miami Aquifer groundwater from Operable Unit 5 can be treated on an interim basis by the AWWT Phase II system.

- Effectiveness: Neither the Phase I nor Phase II AWWT facility would have adequate capacity to handle contaminated groundwater from the Great Miami Aquifer. However, either facility could easily handle anticipated volumes of contaminated perched groundwater removed during remediation at the site. Treatment of perched groundwater by these facilities should meet remedial goals, because each of the individual treatment processes within the Phases I and II AWWT facility passed all screening steps in the evaluation of technologies and process options (see previous sections for individual evaluations). AWWT Phases I and II address treatment of all COCs in the contaminated water including organics (carbon adsorption), uranium (chemical precipitation/ion exchange), and other radionuclides and inorganics (chemical precipitation and/or ion exchange). No apparent impact to the environment would occur upon implementation of this option; however, a potential risk to human health exists from the disposal and handling of the residuals produced by the filtration, activated carbon, and ion exchange processes, and the ion exchange regeneration chemicals.

- Implementability: Because the AWWT Phases I and II facility is already designed and currently in the construction phase, treatment of perched groundwater would be easily implementable. General construction permits have already been acquired for the implementation of these facilities.

- Cost: Because these treatment facilities are already designed and currently in the construction phase, additional capital costs would be negligible. O&M costs, including

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replacement resins, adsorbents, filter media, chemicals, and disposal of process residues, would be high.

The AWWT (Phases I and II) facility is a viable physical/chemical process option and has been retained in the formation of remedial alternatives as the representative primary option for treating perched groundwater, storm water, and process wastewater.

M.4.5.5 Biological Treatment Technologies

The only process option evaluated under the biological treatment technology is biosorption.

Biosorption

Biosorption uses an algae-based resin to adsorb heavy metal ions from an aqueous solution. This process option could be applicable to all contaminated groundwater, storm water, and process wastewater for the removal of radionuclides and inorganic COCs.

- Effectiveness: Biosorption is an innovative technology that has successfully removed uranium, heavy metals, and other radionuclides from contaminated water in pilot plant testing. It could be applied to remove inorganic and radionuclide COCs such as arsenic, barium, lead, manganese, cadmium, mercury, uranium and technetium. This is a relatively new process that may be considered a modification of the conventional ion exchange method. No apparent impact to the environment would occur upon implementation of this option; however, a potential risk to human health exists from the disposal and handling of the residuals produced by the biosorption process.

- Implementability: Biosorption would be difficult to implement due to the fact that it uses a proprietary sorption technique, and the availability of proven equipment and experienced skilled workers could be limited. The resin would probably be used once then disposed of at an off-site facility due to radiological contamination.

- Cost: Capital costs and O&M costs are expected to be high for this process option. Capital costs include extensive studies, design, equipment, installation and instrumentation. O&M costs would include replacement resin and/or residual disposal.

Although biosorption is a viable process for the removal of inorganic and radionuclide COCs from contaminated water, this process is merely a form of ion exchange which uses algae as the resin. Biosorption will not be retained as a biological treatment process option for incorporation into remedial action alternatives due to its lack of an applied track record and the greater availability of similar more proven technologies.

M.4.6 DISPOSAL/DISCHARGE

The technologies considered for the disposal/discharge of treated perched and Great Miami Aquifer groundwater, storm water, and process wastewater include on-property, on-property/off-property, and off-property.

M.4.6.1 On-Property Disposal/Discharge Technologies

Process options evaluated under the on-property disposal/discharge technology include:

- Beneficial reuse
- Discharge to Paddys Run.

Beneficial Reuse

This process option considers use of the existing treated discharge for site process water. Beneficial reuse would be applicable to all treated water. Given the expected volume of treated water, total reuse would not be possible; however, partial reuse as makeup water to the site's various remediation and treatment processes would be a more likely scenario. Reuse for potable water is not a consideration.

- Effectiveness: Partial beneficial reuse of treated water should be effective if all COCs are treated to the necessary makeup water requirements. This process, if used in conjunction with other disposal processes, will be effective in reducing the volume of treated water required to be disposed of through the other options. No adverse impact to human health or the environment would occur upon implementation of this option.

- Implementability: Beneficial reuse would be readily implementable, requiring only a large makeup water tank and distribution system to be added.

- Cost: The capital and O&M costs for partial reuse are expected to be low. Capital costs would include the installation of a makeup tank, pumps and distribution lines. O&M costs would include equipment maintenance and line inspections.

Partial reuse of treated effluent is effective and implementable and has been retained as a support option to be used in conjunction with other disposal process options.

Direct Discharge to Paddys Run

This process option would discharge all treated water through a discharge line to Paddys Run, which is located within the FEMP property boundary.

- Effectiveness: Discharge of treated effluent to Paddys Run could potentially be effective, provided all discharge permit requirements regarding COC concentration limits are satisfied.

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- Implementability: Discharge of treated effluent to Paddys Run would be implementable. Construction of a discharge pipeline from the treatment plant to Paddys Run could be easily accomplished. The FEMP currently holds an NPDES discharge permit, allowing the discharge of treated water to the Great Miami River. Discharging to Paddys Run, an intermittent stream, instead of the Great Miami River would likely result in more stringent discharge limits assigned by regulatory agencies, because of the lower dilution factors provided by Paddys Run.

- Cost: Capital costs and O&M costs are expected to be low for this process option. Capital costs include materials and labor required to connect the proposed discharge line to Paddys Run. O&M costs would include maintenance and monitoring costs.

Discharge of treated water to Paddys Run generates greater concerns regarding effectiveness and implementability than discharging the treated water to the Great Miami River, which will be maintained as a disposal option. Therefore, this disposal option will not be retained for incorporation into remedial action alternatives.

M.4.6.2 On-Property/Off-Property Disposal/Discharge Technologies

The only process option evaluated under the on-property/off-property disposal technology is surface/subsurface discharge.

Surface/Subsurface Discharge

Surface/subsurface discharge, which includes the use of spray irrigation or injection wells to reinject treated groundwater into an aquifer, would be applicable only to Great Miami Aquifer groundwater. Injection wells can be coupled with extraction wells to create a closed system in which extraction and injection rates are balanced.

- Effectiveness: Surface/subsurface discharge is a reliable and effective means of disposing of the volumes of treated water generated by the site's groundwater pump and treat system. Injection wells offer the advantage of decreasing groundwater remediation time by increasing the groundwater flow rate through the Great Miami Aquifer. This option can be effective in diverting contamination away from receptor wells, but would have to be used in conjunction with treatment technologies to achieve remedial goals. The COCs effluent quality limits for subsurface discharge would probably be more stringent than discharge to the Great Miami River, because the groundwater may need to be treated to achieve Great Miami Aquifer background conditions or drinking water standards.

- Implementability: Installation of a well system for underground injection is implementable; however, achieving a closed aquifer recirculation system may be difficult, considering the large volume of water to be treated. Reinjected water that is not captured by the extraction wells could potentially force contaminated groundwater into lesser contaminated areas. Periodic groundwater monitoring would be required to assess whether or not this condition is occurring. With the Great Miami Aquifer

considered a sole-source drinking water aquifer, it is uncertain that underground injection of treated groundwater would be allowed by local or state regulatory agencies. There would be minimal impacts to human health and the environment during the implementation of a reinjection system.

- Cost: The capital and O&M costs for subsurface discharge are expected to be moderate. Capital costs for subsurface discharge are higher than for surface discharge. O&M costs would include maintenance of wells and pumps, electricity, and sampling and laboratory analysis costs.

Due to questionable implementability considerations, including the potential difficulty of obtaining necessary regulatory approvals, surface/subsurface discharge will be eliminated from further consideration as a disposal option for treated site effluents in the formation of remedial alternatives. The process will be retained for consideration as a possible support option to be used to improve the efficiency of groundwater extraction well systems.

M.4.6.3 Off-Property Disposal/Discharge Technologies

The only process option evaluated under the off-property disposal technology is direct discharge of treated groundwater, storm water, and process wastewater to the Great Miami River.

Discharge to Great Miami River

This process option would discharge all treated Great Miami Aquifer and perched groundwater, storm water, and process wastewater through an enclosed pipeline to the Great Miami River, located about 1.5 miles southeast of the FEMP property boundary.

- Effectiveness: Discharge of treated effluent to the Great Miami River would meet the remedial objectives. The FEMP currently holds an NPDES discharge permit, allowing the discharge of treated water to the Great Miami River. Discharge standards for COCs not presently on the NPDES permit would have to be obtained and complied with. The uranium content of the existing discharge is regulated by internal DOE derived concentration guides rather than the current NPDES permit.

- Implementability: Discharge of treated effluent to the Great Miami River would be easily implementable. Construction of the discharge pipeline has been completed. Potential modification of the existing NPDES discharge permit to accommodate additional flow and potential contaminants other than uranium may be necessary. Implementing this option would cause no adverse impact to human health or the environment.

- Cost: Capital costs and O&M costs are expected to be low for this process option. Capital costs include materials and labor required to connect treated effluent streams to the recently completed pipeline. O&M costs would include maintenance and monitoring costs.

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Discharge of effluent to the Great Miami River through a discharge pipeline is a viable process option. This process is effective and implementable, and will be retained for incorporation into the remedial alternatives as the representative primary disposal option for all treated site effluents.

M.5.0 EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL AND SEDIMENT

In this section of Appendix M, the technologies and process options for soil and sediment which have passed the initial screening are considered for further evaluation. The purpose of the evaluation is to obtain a reasonable number of process options to combine into remedial alternatives in Section 4.0 of this FS. The technologies and process options remaining after the initial screening were evaluated based on effectiveness, implementability, and cost. The process options within each technology type were then compared, and the preferred or representative process options were selected for incorporation into remedial action alternatives.

Table M.5-1 summarizes the results of the evaluation of technologies and process options for soil and sediment. Shaded areas in this table represent those process options and/or technologies that have been eliminated from further consideration. Table M.5-2 presents the technologies and process options that will be retained for consideration in the development of remedial alternatives for soil and sediment at Operable Unit 5. In these tables, the technologies are organized according to the general response actions developed in Section 3.1 of this FS. Retained process options are listed by type (primary or support and representative).

Following is a description of the evaluation process for each of the soil and sediment process options which passed the initial screening procedure in Section 3.0 of this appendix.

M.5.1 NO ACTION

The no-action response is retained for development into an alternative as required by CERCLA. It is considered to provide a baseline level to which other remedial technologies and alternatives can be compared. Under this scenario no containment, removal, or treatment of the contaminants in any soil or sediment would occur. In addition, it is assumed that any existing institutional controls would be discontinued and the property released for unrestricted use.

- Effectiveness: The no-action response would not achieve any of the remedial action objectives nor provide for the adequate long-term protection of human health. This response would not attain human health-based goals or comply with ARARs. The contaminated groundwater plumes will continue to enlarge and thereby contaminate currently unaffected areas. The no-action option would provide no additional reduction in the toxicity, mobility, or volume of contaminants in the Great Miami Aquifer and perched groundwater other than that offered by the natural environment. Over time, the potential for exposure would increase as contaminants continue to be released to the groundwater. The degree of contamination in the groundwater would decrease through natural attenuation and dilution over a long period of time (i.e., greater than 1000 years) provided that no new sources of contamination were generated.

TABLE M.5-1
SUMMARY OF EVALUATION OF
TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL AND SEDIMENT
(Shaded Process Options and/or Technologies have been eliminated from further consideration)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
No Action	None	Not Applicable	Not effective in protecting public health or the environment.	No actions would be implemented.	None.	None.
Institutional Controls	Monitoring	Surface Water Monitoring	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of water treatment system.	Readily implementable.	Low; includes installation of automated monitoring system.	Low; includes sampling and analyses.
		Groundwater Monitoring	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of groundwater recovery system.	Readily implementable.	Low; new wells may need to be installed.	Low; includes maintenance, sampling, and analyses.
		Leachate Monitoring	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of remedial actions.	Readily implementable.	Low; new collection sumps may need to be installed.	Low; includes sampling, and analyses.
	Access/Use Restrictions	Physical Barriers	Indirectly achieves human health objectives by preventing access; does not meet environmental objectives since contaminants are left in place.	Readily implementable.	Low; includes materials and installation and is dependent on the extent of the area to be enclosed.	Negligible.
		Security Guards	Indirectly achieves human health objectives by limiting allowable site activities; does not meet environmental objectives since contaminants are left in place.	Readily implementable; physical barriers required for long term implementation.	Negligible.	Low; salaries for security personnel and administrative costs.

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TABLE M.5-1
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Institutional Controls (continued)	Access/Use Restrictions (continued)	Deed Restrictions	Indirectly achieves human health objectives by limiting allowable site activities; does not meet environmental objectives since contaminants are left in place.	Readily implementable within facility boundary; not implementable for off-site property.	Negligible.	Negligible.
		Continued Federal Ownership	Indirectly achieves human health objectives by limiting allowable site activities; does not meet environmental objectives since contaminants are left in place.	Readily implementable; maintains status quo.	Negligible.	Negligible.
Containment	Capping	Multilayer Cap	Does not reduce toxicity, mobility or volume of contaminants; reduces the potential for migration by limiting infiltration and erosion.	Materials, equipment, and skilled labor are readily available.	Moderate; includes costs for material and installation and is dependent on the extent of the area to be capped.	Low; limited to inspections, repairs, and maintenance.
	Surface Water Control	Diversion/ Collection	Would minimize run-on, run-off, erosion, infiltration and, therefore, contaminant migration.	Readily implementable.	Moderate; includes materials and labor.	Low; minimal maintenance.
		Grading	Would be effective in contouring the surface to prevent run-on and run-off and to minimize infiltration, and, therefore, contaminant migration.	Readily implementable.	Moderate; includes materials and labor.	Low; minimal maintenance.
		Revegetation	Would be effective in minimizing erosion by wind and water and, therefore, contaminant migration.	Readily implementable.	Low; includes labor and materials.	Low; minimal maintenance.

TABLE M.5-1
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Removal	Excavation	Excavation	Effective in removing contaminated media so it no longer is a threat to human health and the environment.	Conventional techniques are readily implementable; equipment and materials are readily available.	Low; includes equipment and labor.	Negligible.
		Sorting/Separation	Would be effective in segregating contaminated soil from noncontaminated soil.	Implementable, although low contaminant levels may be difficult to detect with hand-held instruments.	Moderate; includes instruments for analysis.	Low; includes sampling and analysis, and monitoring.
Treatment	Physical	Dewatering/Drying	Would be effective in reducing moisture content of solids (soil and treatment residuals).	Readily implementable.	Moderate; includes equipment, labor and utility costs.	Negligible.
	Physical/ Chemical	Soil Washing	Has proven effective in removing soil contamination (uranium) in pilot plant testing; emerging technology; additional treatability studies required.	Required equipment readily available; would require a large compliment of operators and large quantities of chemicals.	High; includes equipment, power, operators, treatment chemicals, and material and residual handling.	Low, includes long-term monitoring of treated soil.
		Physical Separation	Achieve waste minimization through volume reduction; emerging technology; additional treatability studies required	Required equipment readily available; minimum number of operators required to run the system	Low; includes equipment, power, operators, and material and residual handling	Low; includes long-term monitoring of treated soil.

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TABLE M.5-1
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (Continued)	Solidification/ Stabilization	Cement-/Pozzolan-Based Solidification	Effective in immobilizing radionuclides and inorganics; effectiveness for organics depends on concentration and mobility of compounds.	Uses commonly available techniques, and equipment.	High; includes equipment, reagents, labor, and power usage.	Low; includes long-term monitoring and maintenance of solidified area.
		Thermoplastic Solidification	Has not been applied to radioactive waste; long-term stability and leachability are uncertain.	Requires special equipment and highly trained operators.	High; includes specialized equipment and reagents, trained operators, and power.	Low; includes long-term monitoring of stabilized materials.
		Organic Polymer Stabilization	Questionable effectiveness; used more for ease of waste handling rather than long-term security of wastes.	Requires special equipment and highly trained operators.	High; includes specialized equipment and reagents, trained operators, and power.	Low; includes long-term monitoring of stabilized materials.
		Vitrification	Effective in treating hazardous waste and immobilizing radionuclides. Developed specifically for application to radioactive waste sites.	Most techniques not commercially available, but can be made available for DOE sites. Requires special equipment and highly trained operators.	High; includes equipment, utility costs, and operators.	Low; includes long-term monitoring of stabilized materials.
	Thermal	Thermal Desorption	Effective for removal of organics. Not effective in removal of inorganics or radionuclide constituents of concern (COCs).	This process is both technically and administratively feasible and readily implementable. Mobile units are available.	High; includes equipment, labor and utility costs.	Low; includes maintenance and monitoring.

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TABLE M.5-1
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (continued)	Thermal (continued)	Rotary Kiln Incineration	Effective for removal of organics. Not effective in removal of inorganics or radionuclide COCs. Effective in both long-term and short-term.	This process is both technically and administratively feasible and readily implementable. Mobile units are available.	High; includes equipment, labor and utility costs.	Low; includes maintenance and monitoring.
		Fluidized Bed Combustion	Effective for removal of organics. Not effective in removal of inorganics or radionuclide COCs. Low throughput capacity.	This process is both technically and administratively feasible. Not widely used on hazardous wastes.	High; includes equipment, labor, and utility costs.	Low; includes maintenance and monitoring.
		Circulating Bed Combustion	Effective for removal of organics. Not effective in removal of inorganics or radionuclide COCs.	This process is both technically and administratively feasible and readily implementable. Not widely used on hazardous wastes.	High; includes equipment, labor and utility costs.	Low; includes maintenance and monitoring.
		Infrared Incineration	Effective for removal of organics. Not effective in removal of inorganics or radionuclide COCs.	This process is both technically and administratively feasible and readily implementable. Mobile units are available.	High; includes equipment, labor and utility costs.	Low; includes maintenance and monitoring.
		Plasma Centrifugal Furnace	Effective for treating organics, metals, and radionuclides; most appropriate for highly concentrated wastes.	Process is in research & development stage; problems encountered with emission controls, short electrode life, and volatilization of metals.	High; includes equipment and utility costs.	Low; includes maintenance and monitoring.

TABLE M.5-1
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Storage	Intermediate	Central Storage Facility	Effective in isolating contaminants; not a permanent solution; dependant on continued maintenance.	Design and construction is readily implementable.	Moderate; includes structure, pad, secondary containment and drain system.	Moderate; includes monitoring, maintenance, and security.
Disposal	On-Property	Backfilling	Contingent upon the backfill material meeting the required soil remediation goals.	Equipment, labor and on-property disposal sites are readily available.	Low; includes earthmoving and handling equipment and labor.	Low; includes maintenance and monitoring.
		Engineered Disposal Cell	Effective in isolating contaminated materials so that direct contact threats and contaminant migration are reduced.	Disposal cell design and construction widely practiced; siting will require regulatory approval.	High; cost dependant on volume of material to be landfilled.	Moderate; includes monitoring and maintenance.
		Consolidation	Contingent upon the consolidated material meeting the waste acceptance criteria	Equipment, labor and on-property consolidation sites are readily available.	Low; includes earth moving and handling equipment and labor	Low; includes monitoring and maintenance.
	Off-Site	Nevada Test Site	Radionuclide COCs would be permanently removed from the site; mixed waste (hazardous and radioactive) will not be accepted.	Administratively easy to implement, logistically more difficult; waste must be containerized; no rail line into site.	High; due to disposal fees and packaging costs.	Negligible.
		Permitted Commercial Facility	Radionuclide, organic and inorganic COCs would be permanently removed from the site; mixed wastes would be accepted.	Waste disposal is readily implemented; waste can be received in bulk shipments; a rail line runs directly to the facility.	Moderate; due to disposal fees, no packaging costs required.	Negligible.

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TABLE M.5-1
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Disposal (continued)	Waste Transportation	Truck Transport	Effective in transporting contaminated material on site and off site; provides portal to portal service to sites without rail spurs.	Truck transport is moderately difficult for long distances; notification of regulatory agencies would be required.	Moderate, compared to rail transport; includes construction of access roads.	Moderate; includes fees, maintenance of access roads, loading areas.
		Rail Transport	Effective in transporting contaminated material off site; will require the additional use of truck transport if rail spur not available to disposal site.	Rail transport is readily implemented, some rail upgrades may be required; highly reliable and safe.	High, compared to truck transport; includes upgrading on-site rail spur and loading areas.	Low; includes rail fees.

TABLE M.5-2

SUMMARY OF RETAINED SOIL AND SEDIMENT TECHNOLOGIES AND PROCESS OPTIONS

General Response Action	Remedial Technology	Process Option	Primary	Support	Representative Process Option[a]
No Action	None	Not applicable	X		
Institutional Controls	Monitoring	Surface water monitoring		X	X
		Groundwater monitoring		X	X
		Leachate monitoring		X	X
	Access/Use Restrictions	Physical barriers		X	X
		Security guards		X	X
		Deed restrictions		X	X
		Continued Federal ownership		X	X
Containment	Capping	Multilayer cap	X		X
	Surface Water Controls	Diversion collection		X	X
		Grading		X	X
		Revegetation		X	X
Removal	Excavation	Excavation	X		X
		Sorting/separation		X	X
Treatment	Physical	Dewatering/drying		X	X
	Physical/Chemical	Soil washing		X	
		Physical separation		X	
	Solidification/ Stabilization	Cement/pozzolan-based solidification		X	
		Vitrification		X	
	Thermal	Thermal desorption		X	X
		Rotary kiln incineration		X	
		Infrared incineration		X	
Storage	Intermediate Storage	Central storage facility		X	X
Disposal	On-Property	Backfilling	X		X
		Engineered disposal cell	X		X
		Consolidation	X		X
	Off-Site	Nevada Test Site	X		
		Commercial disposal facility	X		X
	Waste Transportation	Truck transport		X	X
		Rail transport		X	X

[a] The representative process options have been selected for incorporation into the remedial alternatives. Their selection does not preclude the use of other retained process options in the remedial design.

- Implementability: No remedial actions would be implemented under the no-action response.

- Cost: There are no capital costs or O&M costs associated with the no-action response.

As required by the NCP, the no-action response is retained for further evaluation as a baseline comparison for other remedial action alternatives.

M.5.2 INSTITUTIONAL CONTROLS

The technologies considered for institutional controls include access/use restrictions and monitoring.

M.5.2.1 Monitoring Technologies

Process options considered for this technology include:

- Surface water monitoring
- Groundwater monitoring
- Leachate monitoring.

Surface Water Monitoring

Surface water monitoring is applicable to contaminated soil and sediment because surface water can act as a transport mechanism for contaminants. Additionally, surface water sampling may be required in conjunction with on-property disposal or containment options. Sampling and analysis of collected storm water would be required for any water discharged to local surface streams. Surface water monitoring can also be helpful in evaluating potential surface water contaminant migration and the effectiveness of remedial treatment activities.

- Effectiveness: Surface water monitoring would not reduce the toxicity, mobility, or volume of contaminants in the surface water. Also, monitoring would not provide any additional protection of the environment since the contaminated surface water would continue to migrate to off-site areas. Monitoring will be helpful in measuring and evaluating the effectiveness of remedial actions. Potential impacts on human health and the environment during implementation would be minimal. Exposure for sampling and analytical personnel would also be minimal.

- Implementability: Surface water monitoring is implementable. Equipment and services are readily available. While CERCLA response actions are exempt from administrative requirements like NPDES permits, the substantive information typically found on permit applications would be required to be provided to the state for any proposed point source discharges to the Great Miami River or Paddys Run.

- Cost: For surface water monitoring only, capital and O&M costs would be relatively low. O&M costs would include labor to collect samples, laboratory analysis, and data validation/management.

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Surface water monitoring would be effective in monitoring contaminant migration and the effectiveness of remedial actions. Surface water monitoring will be retained as a support option to be used in conjunction with other process options in the formation of alternatives.

Groundwater Monitoring

Groundwater monitoring, sampling, and analysis of selected wells can be used to assess the concentration levels and movement of the COCs. Monitoring of groundwater can also be helpful in evaluating the progress of other remedial activities.

- Effectiveness: Groundwater monitoring would not reduce potential threats to human health and the environment. Potential exposure to contaminants by sampling personnel would be negligible. There would be no threats to the environment associated with groundwater monitoring. Groundwater sampling and analysis are reliable and proven techniques for monitoring purposes.

- Implementability: Groundwater monitoring is readily implementable. There are presently numerous wells at the FEMP site, and additional wells could be easily installed, if needed. Minimal administrative complexities, including permit applications, are envisioned for monitoring well installation.

- Cost: The only capital costs that may be incurred would be for the installation of additional monitoring wells, if needed. Easements may be required for the installation of off-property wells. Annual costs would be incurred for monitoring well maintenance and groundwater sampling and analysis. Capital and O&M costs are considered low.

Groundwater monitoring would be appropriate as either compliance monitoring or response action monitoring. It would be effective and readily implementable, and is retained as a support process for incorporation into remedial action alternatives.

Leachate Monitoring

Leachate monitoring is applicable to site soil and sediment. Sampling and analysis of on-property leachate streams could be used to evaluate the progress of other remedial activities.

- Effectiveness: Leachate monitoring would not reduce the toxicity, mobility, or volume of contaminants in the perched groundwater. Also, monitoring would not provide any additional protection of the environment since the contaminated groundwater would continue to migrate into the Great Miami Aquifer. Monitoring would be helpful in measuring and evaluating the effectiveness of remedial actions. Potential impacts on human health and the environment during construction and implementation would be negligible. Exposure for sampling and analytical personnel would also be negligible.

- Implementability: Leachate monitoring is easily implementable. It only involves the sampling and analysis of collected leachate seeps or streams. Equipment and services are readily available.

- Cost: For leachate monitoring only, capital and O&M costs would be relatively low. Capital costs would include the possible installation of a few collection sumps. O&M costs would include sampling, laboratory analysis, and data validation/management.

Leachate monitoring would be effective in observing, but not controlling contaminant migration. Leachate monitoring would be implementable. As a result, leachate monitoring will be retained as a support option for soil and sediment to be used in conjunction with other process options in the formation of remedial alternatives.

M.5.2.2 Access/Use Restrictions

Process options considered for access/use restrictions include:

- Physical barriers
- Security guards
- Deed restrictions
- Continued federal ownership.

Physical Barriers

Physical barriers consist of fences, structures, and controls implemented at a hazardous waste and/or materials site to reduce human contact with the contaminants by preventing individuals from entering the site. Physical barriers would include a site perimeter fence with locked gates. This option may also include the installation of markers to delineate areas where hazardous materials or contaminants remain on the FEMP property. These barriers would discourage trespassing and require individuals to enter through security gates and controlled entrances.

- Effectiveness: Physical barriers would be an effective method for isolating and defining the area required to handle, treat, or dispose of contaminated material. Physical barriers alone are not effective in meeting remediation goals because they provide no reduction in the toxicity, mobility, or volume of contaminants. However, when used in conjunction with other technologies, physical barriers can assist in meeting remediation goals and are effective in protecting human health by restricting public access to a waste site. Physical barriers are only minimally effective in protecting the environment as contaminants could continue to migrate into the environment through groundwater, soil, surface water, and the atmosphere; however, physical barriers would limit access of certain animals to the waste site. The construction of physical barriers would have a negligible impact to both human health and the environment. Physical barriers are a reliable and proven method of restricting access of the general public to a waste site; however, they can be breached during acts of vandalism or vagrancy. Maintenance of the barrier would be required to ensure its effectiveness over the long term.

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- Implementability: Physical barriers are administratively feasible and require no special permitting to implement. Physical barriers are currently in place; however, additional barriers and continued maintenance activities would be required for long-term implementation.

- Cost: The capital costs necessary for physical barriers include materials and labor and are dependent on the extent of the area(s) to be enclosed. Once the physical barriers are installed, there would be minimal maintenance requirements and O&M costs. Costs are expected to be low.

Physical barriers would be effective in restricting access and direct contact by humans; but would not remove the potential for contaminant migration. Physical barriers are retained as a support action for incorporation into remedial action alternatives.

Security Guards

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

- Effectiveness: Security guards are effective in supplementing physical barriers. Security forces would monitor the physical barriers for breaches. Random patrols would discourage vandalism or vagrancy. Security guards would physically remove trespassers that did breach the barriers. Security guards provide no reduction in toxicity, mobility, or volume of contaminants, but are effective in protecting human health by restricting public access to the contaminated media. Security guards are a reliable and proven method of restricting access of the general public to a waste site.

- Implementability: Security guards are administratively feasible. Security forces are currently on site. Physical barriers would be required for long term implementation to assure boundaries are properly delineated.

- Cost: There are no capital costs associated with security guards. O&M costs would be relatively low.

Security guards are retained for further consideration as a support action to be used in conjunction with physical barriers.

Deed Restrictions

Deed restrictions may be potentially applicable for areas containing contaminated soil. Deed restrictions are a legal form of administrative control that would prohibit specified land use activities. Limited land use may include prohibiting well drilling, farming, earth excavation operations, and/or erection of buildings.

- Effectiveness: Deed restrictions would be effective in placing legal restraints on the future use or development of areas used to contain or dispose of contaminated material on the FEMP property. Deed restrictions can be effective in protecting human health by restraining agricultural, construction, or other usage or development activities that could increase public exposure to the contaminated material. Deed restrictions can also be used to reduce public access to a waste site; however, they are only minimally effective at limiting public access unless used with other institutional controls (i.e., physical barriers). Deed restrictions alone would provide no protection to the environment, since the contaminated material would remain in place without treatment and wildlife access to the site would not be restricted. However, deed restrictions could prevent the drilling of wells into the underlying contaminated groundwater.

- Implementability: Deed restrictions are administratively feasible; however, deed restrictions are susceptible to changes in laws governing the transfer of property, deed adherence, and enforcement. Deed restrictions do not require any special resources to implement. Legal services would be required to implement deed restrictions. No consideration is being given in this FS to implementing deed restrictions on off-property areas through the purchase of land.

- Cost: Capital costs for this option include legal fees and are considered negligible. There are no annual O&M costs associated with this option.

Deed restrictions would be somewhat effective in restricting access and direct contact by humans, but would not remove the potential for contaminant migration. Deed restrictions are retained as a support action for incorporation into remedial action alternatives.

Continued Federal Ownership

Continued federal ownership is applicable to on-property soil and sediment. In this process option, the federal government could restrict or eliminate contact with contaminated soil or sediment on-property by continuing to exercise its rights as a property owner. The property owner would continue custodial oversight of the property through the DOE or another government entity.

- Effectiveness: Continued federal ownership would not reduce the toxicity, mobility or volume of contaminants in the groundwater; however, it would reduce the potential risk to human health by using property ownership rights to limit potential exposure associated with contaminants contained on the FEMP property. Physical barriers would also be required to maintain the access limitations of the facility.

- Implementability: This option is readily implementable and administratively feasible as it represents the continuation of the existing situation with respect to property ownership.

- Cost: Because the implementation of this option does not require the transfer of property ownership, capital and O&M costs would be negligible.

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Continued federal ownership is retained as a support action for use with other institutional actions and containment options in the formation of the alternatives.

M.5.3 CONTAINMENT

The technologies considered for containment include capping and surface water control.

M.5.3.1 Capping Technologies

Capping consists of the construction of a barrier that confines contaminated media to its current location. Capping is used to minimize infiltration, reduce transport of exposed waste materials, and minimize the potential for direct contact with contaminants. Capping typically involves the installation of a low-permeability compacted soil and/or synthetic liner over the waste or contaminated soil, and includes an overlying layer of topsoil and vegetation to protect the low-permeability barrier. Often, regrading of surface soil and relocation of the contaminated material within the area to be capped is required to maintain the proper side slopes on the cap in order to provide internal stability of the cap components and surface water control. The capping technologies reduce contaminant migration, but they do not reduce contaminant toxicity or volume. Capping is effective at reducing risks of exposure to the contaminated material.

The only process option considered for this remedial technology is multilayer capping.

Multilayer Cap

Multilayer capping involves the installation of a barrier over the surface of the contaminated area. Capping can be used to control direct contact exposure and reduce the migration of contaminants to air, surface water, and groundwater. The cap would consist of a combination of low-permeability materials such as clay, concrete, asphalt, geotextiles, and synthetic membranes.

The current design standards for mixed low-level radioactive and hazardous waste landfill caps commonly include: (1) an outer rock or vegetative layer to minimize erosion and provide for long-term stability, (2) a filter and drainage layer that transmits infiltrated water away from underlying low permeability layers to prevent ponding, and (3) an impervious flexible membrane overlying a compacted low-permeability clay layer.

- Effectiveness: This option provides protection of human health by minimizing the potential for direct contact with or ingestion of contaminated soil and sediment. The primary COCs which pose the greatest threat by ingestion and/or dermal contact include: PAHs (e.g., benzo(a)anthracene, chrysene, and benzo(a)pyrene), radium, thorium, and arsenic. It also reduces the potential for contaminant migration to air, surface water, and groundwater and for plant and/or aquatic life uptake. The cap will prevent surface water from filtering through the soil contaminated with uranium, the COC which poses the greatest risk to the groundwater. The only threats to human

health and the environment during construction would be fugitive dust emissions, which can be readily controlled by using dust suppressants and PPE. Capping is proven and reliable, if properly maintained. A multilayer cap would ensure the long-term isolation of contaminants in the event that one layer failed.

- Implementability: Materials, equipment, and skilled personnel for the installation of a cap are readily available and acceptance from regulatory agencies for use with hazardous wastes is feasible.

- Cost: Capital costs include material and installation costs. These costs are dependent on the type of capping materials and the extent of the area to be covered and are considered moderate. O&M costs are limited to inspections on a regular basis and any subsequent repairs or maintenance. O&M costs are considered low.

The multilayer cap is a viable process option for control and containment of contaminated soil and sediment. It is retained for incorporation into remedial action alternatives as the primary representative process option for capping technologies.

M.5.3.2 Surface Water Control Technologies

Surface water controls evaluated include:

- Diversion/collection
- Grading
- Revegetation.

Diversion/Collection

Diversion/collection would be used to control run-on and runoff from a waste area or a disposal facility. Diversion would be accomplished using dikes and berms; collection would be accomplished by using channels or trenches.

- Effectiveness: Diversion/collection would be effective in reducing infiltration which would help to minimize COC migration. Diversion/collection would not reduce contaminant toxicity, mobility, and volume. Maintenance of a diversion/collection system would be required over the long term.

- Implementability: Diversion/collection would be administratively feasible and require no special permitting to implement. Services to construct diversion/collection systems are readily available.

- Cost: Capital costs are considered moderate and include materials and labor. Once the diversion/collection system is installed, there would be minimal maintenance and no operating costs.

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Diversion/collection of surface water will be retained as a support option in the development of remedial alternatives.

Grading

Grading would be conducted to recontour the surface to limit run-on, runoff and erosion. Grading would be conducted after excavation or for containment options.

- Effectiveness: Grading would be effective in minimizing run-on and erosion concerns from runoff. Grading would also help to minimize infiltration. Grading would not reduce toxicity, mobility, or volume. Maintenance of the graded area may be required over the long term.

- Implementability: Grading is administratively feasible and requires no special permitting to implement.

- Cost: The capital cost necessary for grading includes equipment and labor and is considered moderate. Minimal maintenance and no operating costs would be incurred.

Grading will be retained as a support action for incorporation into remedial alternatives.

Revegetation

Revegetation is a cost-effective method to stabilize the surface, especially after excavation and backfilling. Revegetation decreases erosion by wind and water and contributes to the development of a naturally fertile and stable surface environment. Revegetation is used with removal options.

- Effectiveness: Revegetation can be effective in stabilizing surface soil when used in conjunction with removal technologies that excavate contaminated soil. Revegetation is effective in helping to achieve the remediation goal of protecting the environment by reducing the migration of surface soil into streams. Revegetation is effective at controlling wind and surface water erosion. Revegetation is a reliable method for surface stabilization; however, revegetation is not a reliable method for surface stabilization in areas where strong erosion forces, steep grades, ponding conditions, or infertile soil decreases the effectiveness of revegetation.

- Implementability: Revegetation is administratively feasible and requires no special permitting to implement. Both resources and services required to place a vegetative cover are readily available.

- Costs: Capital costs would include labor and materials. When compared to other surface controls options, revegetation has a low capital cost and low O&M costs.

Revegetation will be retained for incorporation into the alternatives as a support for removal actions.

M.5.4 REMOVAL

Under this technology, soil excavation and sorting/separation are considered.

M.5.4.1 Excavation Technologies

The process options that passed the initial screening for this technology include:

- Excavation
- Sorting/separation.

Excavation

Soil excavation can be accomplished with conventional heavy construction equipment and is applicable to almost all site conditions. Backhoes, hydraulic excavators, graders, and loaders are most appropriate for the removal of soil and dry stream sediment. Sections of Paddys Run, the storm sewer outfall ditch, and the pilot plant drainage ditch are dry during the summer and autumn months; therefore, standard excavation techniques can be accommodated. Conventional excavation techniques can also be used when these streams are flowing if controls are in place to minimize downstream transport of contaminated sediment during excavation.

Large volumes of potentially contaminated soil are also located beneath site buildings and facilities. To excavate this soil, the buildings must first be demolished or excavation must be through the floor of the building.

- Effectiveness: Mechanical excavation effectively removes contaminated soil and sediment. The primary COCs which will be removed include uranium, thorium, radium, arsenic and PAHs. There is a potential risk for worker exposure to short-term fugitive dust emissions during the excavation process. These risks will be minimal provided that PPE and dust suppressants are employed.

- Implementability: The equipment necessary for the removal of site soil and sediment is conventional and readily available. Site conditions are conducive to easy implementation using conventional excavation techniques. The removal of soil or sediment from off-property areas will require access approval and adherence to U.S. Army Corps of Engineers requirements for excavation from Paddys Run. Before excavation of soil underneath a building, a study of the existing building/structure would be required to determine any bracing and/or shoring requirements to ensure that no extensive load displacements occur during the excavation process.

- Cost: The capital costs for soil and sediment excavation would include equipment and labor and are considered low. The cost would increase if buildings were not removed before excavation. There are no annual O&M costs associated with excavation.

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Excavation of soil and sediment is deemed effective and implementable and is retained for incorporation into remedial alternatives as a primary representative process option.

Sorting/Separation

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

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

- Effectiveness: Sorting/separation would be an effective technology for handling the volume of contaminated material present. Sorting/separation would be effective for reducing the total amount of material that would have to be treated or disposed. The use of sorting/separation is not effective by itself in meeting remediation goals; however, it is effective when used in conjunction with other process options. During construction, risks to site workers using field screening equipment can be mitigated by using safe work procedures. Sorting/separation is reliable for visually identifying large debris and sorting using mechanical excavators. The identification process for separating radiologically contaminated materials from nonradiologically contaminated materials is relatively slow.

- Implementability: Sorting/separation is administratively feasible if conservative sorting decisions are made in the field. A method of quality assurance must be developed to calibrate the field readings with laboratory analysis to ensure that material sorted as noncontaminated is, in fact, clean. The resources for sorting using mechanical excavators and mechanical screening are readily available. The currently available resources for sorting radiologically contaminated material are slow. Devices that can identify large quantities of radiologically contaminated material relatively quickly are currently being developed.

- Cost: Capital costs include equipment, labor expenses, and power usage, and are considered to be moderate. O&M costs include sampling and analysis, long-term maintenance, and monitoring of the waste after it is disposed of and are considered to be low.

Sorting/separation will be retained for incorporation into the alternatives as a support action to other technologies that require contaminated waste to be separated before treatment or disposal.

M.5.5 TREATMENT

The technologies considered under treatment include physical treatment, physical/chemical treatment, solidification/stabilization, and thermal treatment.

M.5.5.1 Physical Treatment Technologies

The only process option considered for this technology is dewatering/drying.

Dewatering/Drying

Dewatering is a physical treatment process which is performed to reduce the moisture content of a material by a natural or mechanical process. By separating liquid from the solid material, the volume is greatly reduced and easier to handle. Additional dewatering by means of drying will further reduce the volume.

Drying may include physical or thermal processes. Some thermal processes may require physical drying as a pretreatment step to extract excess water from the raw material before thermal drying. Physical processes include filter presses or spreading the material in drying beds. Filter presses might be suitable for treating residue from a water treatment process option.

Thermal processes are typically classified in two ways, direct and indirect heating. Direct heating methods accomplish drying by direct contact between the wet solids and hot gases. Indirect heating methods dry materials by transferring heat to the wet solids through a retaining wall. Indirect methods minimize dust creation, but are less energy efficient than direct methods. Either method will require air pollution controls such as high-efficiency particulate air (HEPA) filters or scrubbers to contain dust or other emissions such as volatile organics that may be driven off in the process.

The typical methods of dewatering/drying include filter presses, centrifuges, and/or rotary dryers.

- Effectiveness: Dewatering/drying is an effective means of reducing the amount of material being handled as a solid and in some cases is a necessary step to meet specific handling, treatment, and disposal requirements. It does not treat the organic, inorganic or radionuclide COCs, but can be effective as a support process option. Emission control may be necessary to capture any volatiles which are released during drying.

- Implementability: The various methods of dewatering are all readily implementable and they are technically and administratively feasible. The specific process selected will be based on the initial moisture content and the desired final moisture content. Dewatering/drying equipment is readily available.

- Cost: Capital costs associated with this process which include equipment, labor, and utilities are considered to be moderate. O&M costs are negligible.

Dewatering/drying is applicable to soil and sediment, and treatment process residuals, and will be retained for use in the development of alternatives as a support process option in conjunction with other treatment and/or disposal options.

M.5.5.2 Physical/Chemical Treatment Technologies

Process options that passed the initial screening for this technology type include:

- Soil washing
- Physical separation.

Soil Washing

Soil washing is an ex situ treatment process that incorporates the separation of chemical contaminants from the soil matrix by a combination of physical and chemical treatments. Soil aggregates are reduced to a single-grain composition by either mechanical- and/or chemical-based operations, allowing for particle separation based on size and/or density characteristics. Selected physicochemical operations can then aid in the extraction of inorganic, organic, and radiological chemical contaminants from the discrete soil particles.

Limitations to conventional soil washing processes exist. Although this process may significantly reduce contaminant mass and mobility in the final treated soil, it may still not achieve a targeted cleanup criteria due to the indigenous nature of the soil contaminant matrix. The incorporation of additional processing steps (composed of chemical extraction and/or other innovative technologies) to meet targeted cleanup levels may result in a treatment process that is not cost competitive with off-site disposal or on-property consolidation. In addition, generation of secondary waste streams may reduce the net volume reduction. Regeneration of the soil fertility following treatment, in order to support plant life, should not be a major problem given standard agronomic practices.

Several soil washing treatability studies have been conducted on FEMP property contaminated soil using a cross section of extractant methods and reagents. These tests have been conducted under the DOE's uranium in soil integrated demonstration and minimum additive waste stabilization programs, and the FEMP's soil washing treatability studies (refer to Appendix D for more information regarding these programs and studies). All of the DOE programs and most of the FEMP tests focused on removing uranium, the principle site COC.

Based on the results of the treatability studies to date, the following general conclusions are possible: 1) site soil generally contains a high silt/clay fraction; 2) uranium contamination is present in all site soil fractions; 3) a carbonate extraction solution can reduce uranium concentrations in site soil to 100 mg/kg (approximately 80 percent reduction); 4) a sulfuric acid extraction solution can reduce uranium

concentrations in site soil to 50 mg/kg (approximately 90 percent reduction); and 5) the sulfuric acid extractant process generates a relatively greater quantity of treatment residues than does the carbonate extractant process.

The following is an evaluation of the soil washing process:

- Effectiveness: The soil washing process can reduce the concentration of uranium in the site soil by 80 to 90 percent, resulting in an approximately 60 percent net volume reduction. Questions remain about the mobility of the residual uranium remaining in the treated soil. The effect the soil washing process would have on the other radionuclide, organic, and inorganic COCs in the site soil is inconclusive.

- Implementability: A full-scale site soil washing system would require a wide spectrum of treatment equipment and appurtenances, all of which are available through standard equipment suppliers. A relatively large compliment of trained operators would be required, and large volumes of reagent chemicals would have to be shipped to the site on a daily or weekly basis.

- Cost: Capital costs include treatment equipment, large volumes of reagent chemicals, a large compliment of trained operators, and electric power, and are considered high. O&M costs include long-term monitoring and are considered low.

Based on the current level of technological development, the retention of soil washing as a viable remedial technology for Operable Unit 5 soil must be as a support technology within a treatment-train process or as a sole process targeting soil contaminant anomalies, e.g., soil with excessively high concentration or mobility levels of uranium or other contaminants of concern.

Due to the concerns regarding contaminant mobility, the physical characteristics of the treated soil, and the complexity of the operation that a full-scale soil washing system would require, soil washing will not be retained for incorporation into the remedial alternatives. However, there may be certain situations at the Operable Unit 5 site where soil washing could be a potentially viable support option. Treatability studies are continuing in an effort to discover ways to mitigate the concerns identified above and, in general, to improve the technical applicability and economic feasibility of the soil washing process.

Physical Separation

The operational premise for a physical separation process is to derive waste minimization through a volume reduction process by separating out a size fraction of the soil containing little or no contamination. Physical separation operations in soil washing have included high pressure water, screening, attrition scrubbing, froth flotation, tall column, electromagnetic separation, mechanical

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separation, hydrogravimetric separation (including hydrocyclones, mineral jigs, and spiral classifiers), and multigravity separation.

Primary limitations to the application of a physical separation-based soil washing process for Operable Unit 5 soil are the ubiquitous distribution of uranium throughout all soil particle-size fractions and the lack of predominately sand-based soil. In addition, since a number of soil contaminant matrices exist within Operable Unit 5, the effectiveness of water-based physical separation processes will depend on which soil-uranium matrix is being treated. However, significant reduction in contaminant mobility should result from in an oversize treated fraction coming off of the physical separation process.

The following is an evaluation of the physical separation process:

- Effectiveness: A physical separation process has the potential to achieve waste minimization through volume reduction. The use of selective equipment for separating the coarse soil particles, e.g., gravel, sand and possibly the coarse silt fraction as well as dense metal particulates, could result in a soil fraction with residual uranium concentrations and mobility meeting selected targeted cleanup levels by either reducing uranium concentration and/or uranium mobility.

- Implementability: A full-scale site physical separation system would require a much more simplified process than for a full-scale soil washing system. Select equipment would be used to provide specific soil size fractions and dewatering operations within the system. Processing rates would be relative high tonnage per hour with a minimum number of operators being needed to run the system.

- Cost: System design and capital cost for equipment are low. O&M costs include long-term monitoring and are considered low.

Based on the current level of technological development, the retention of a physical separation-based soil washing process as a viable remedial technology for Operable Unit 5 soil must be as a support technology. Although, a physical separation process would certainly be cost competitive with off-site disposal and possibly with on-site consolidation, the nature of the soil contaminant matrix within Operable Unit 5 does not lend itself to a definite resolution on whether the treated soil fraction would achieve the defined cleanup criteria. Its potential application would be as a support technology within a treatment-train process, possibly supported by other innovative technologies, or as a sole process targeting soil which either slightly exceeds cleanup criteria for total uranium concentration or soil with excessively high mobility levels for uranium or other COCs so as to exceed the on-site consolidation criteria.

M.5.5.3 Solidification/Stabilization Technologies

Process options that passed the initial screening for this technology type include:

- Cement-/Pozzolan-based solidification
- Thermoplastic solidification
- Organic polymer stabilization
- Vitrification.

Cement-/Pozzolan-Based Solidification

Cement-based solidification involves sealing excavated wastes in a matrix of portland cement to physically or chemically solidify the waste. Pozzolan-based solidification is very similar to cement-based though the solidification agent is a mixture of fine-grained siliceous material, lime, and water. Other materials, such as flyash, cement-kiln dust, or ground blast-furnace slag can be used as the siliceous additive. Weight and volume increases are typical for the final product of cement-based solidification processes. Pozzolan-based methods also result in weight and volume increases.

Solidification technologies are applicable to contaminated material whose primary COCs are inorganics and radionuclides. This technology reduces mobility through the binding of hazardous constituents into a solid mass with low permeability that resists leaching, or by chemically binding them to the solidification reagents and thereby resisting leaching. Solidification agents typically include pozzolanic-based materials such as portland cement, cement kiln dust, and flyash. Additives such as lime or proprietary reagents are often added to the solidification formula to increase the effectiveness of the treatment. Specifically, lime can be added to reduce the solubility of metals and organophilic clay can be added to adsorb organic contaminants.

Solidification technologies have been most successful when applied to inorganic waste streams, sludge, contaminated soil containing nonvolatile organics such as PCBs and creosote, and incinerator ash containing heavy metals (EPA 1988b). Solidification is often used to pretreat radiologically contaminated wastes before disposal.

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

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

The performance of a solidification system is highly waste specific; therefore, the process must be designed to accommodate the specific waste. A thorough physical and chemical characterization of waste and treatability testing is essential to determining the most suitable solidification reagents and mixing ratios, as well as any special pretreatment or material handling methods that may be required.

The equipment used in solidification includes a feed system (conveyor or hopper), mixing vessels (pug mill or containers with excavating equipment), and bulk storage bins. After the waste is mixed with the solidifying agents the material is allowed to cure for a specified time period which is dependent on the strength required before handling or disposal. The solidified waste can be in the form of a treated block or a modified soil which can be compacted in a disposal area using standard construction equipment.

- Effectiveness: Cement-based or pozzolan-based (lime or flyash) solidification methods can be effective in immobilizing radioactive and inorganic COCs. The effectiveness in immobilizing organics depends on the concentration and mobility of the organic compounds. Solidification of contaminated soil will reduce the leachability of the primary radionuclide and inorganic COCs, including uranium, thorium, radium and arsenic. The mechanism to reduce leachability may be a result of pH adjustment or by the addition of a reagent which will chemically bind the contaminant to the solidified matrix. A treatability study will be required to determine optimum mix ratios and the need to add special reagents to reduce mobility of the contaminants. The primary organic COCs are PAHs (e.g., benzo(a)anthracene, chrysene, and benzo(a)pyrene). These organics are relatively immobile and primarily present risks from direct contact. Solidification will minimize migration of the PAHs; however, the solidified mass will require some type of cover to eliminate the risk of dermal contact. The solidification process would be effective in eliminating direct exposures to receptors and in minimizing the leaching of soil and sediment contaminants to other environmental media. Long-term stability and leachability, however, are potential concerns because the contaminants are not destroyed, but remain within the solidified mass. This type of solidification also results in a volume increase.

- Implementability: The equipment necessary for this process is similar to that used for cement mixing and handling. It includes a feed system, mixing vessel, and a curing area. A solidification process will require bulk storage for the solidification agents such as cement and flyash. The solidification agents will be metered at controlled rates using weight feeders. The solidification agents will be pneumatically fed to a pug mill where the soil and cement additives will be blended. The final mix will be deposited into reusable forms for curing. After curing, the solid blocks will be removed from the

forms and transported to the appropriate disposal destination. No permits, except for construction permits, would be required for an on-property treatment system.

- Cost: Capital costs include equipment, reagents, labor expenses, and power usage and are considered high. O&M costs include long-term maintenance and monitoring of stabilized areas and are considered low.

Due to concerns involving long-term stability, high reagent consumption, and significant volume increases leading to higher disposal costs, this process option will not be retained for incorporation into the remedial alternatives. However, there may be applications such as certain types of waste treatment residuals or smaller areas of soil containing very high inorganic and radionuclide concentrations where cement- and pozzolan-based solidification could be a potentially viable support option.

Thermoplastic Solidification

Thermoplastic encapsulation involves sealing a waste in a matrix by the addition of a binder. The binder material may be asphalt bitumen, paraffin, sulfur cement, polystyrene, or polyethylene. The waste is dried, heated, and mixed with a heated binder material. The heated (266°F to 500°F) waste-binder mixture is placed in a container or mold where it solidifies as it cools.

Thermoplastic encapsulation reduces the hazard potential of a waste by physically surrounding the waste and containing it in a less soluble, mobile, and/or concentrated form. Because there is no chemical reaction associated with this remedial technology, there is a decreased possibility that the waste would be incompatible with the binder. This technology will result in a volume increase due to the addition of the binder material.

Thermoplastic techniques include both micro- and macro-encapsulation processes. Micro-encapsulation isolates and surrounds individual particles and macro-encapsulation produces a solid mass of particles surrounded by a thermoplastic container. Macro-encapsulation, also called jacketing, isolates the waste by completely surrounding it with a durable, impermeable coating. Methods include sealing the waste in polyethylene or in a polyethylene-lined drum or mixing the waste with an organic polymer and then compressing the mixture into a polyethylene-coated block using a pressure/heating technique.

Bench-scale thermoplastic encapsulation of DOE Rocky Flats wastes was performed by Brookhaven National Laboratory (BNL). The low-level radioactive wastes included in the thermoplastic encapsulation bench-scale testing were reactor-generated evaporator concentrate salts (sodium sulfate and boric acid), incinerator ash, and ion exchange resins. Full-scale thermoplastic encapsulation of a simulated nitrate salt waste was also successfully performed by BNL. BNL reports that thermoplastic

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encapsulation cannot be used for waste that contains highly volatile organics unless the waste is pretreated for their removal.

- Effectiveness: Solidification of contaminated soil will reduce the leachability of the primary radionuclide and inorganic COCs, including uranium, thorium, radium isotopes, and arsenic. This method is most applicable to heavy metals. Relative to cement-based solidification, the increase in volume and rate of leaching is significantly less. The energy intensity of the operation (to heat the thermoplastic material to a liquid) is increased by the requirement that the wastes be thoroughly dried before solidification. The primary organic COCs, which include benzo(a)anthracene, chrysene, benzo(a)pyrene and other PAHs, will be treated during this process. This process has not been applied full-scale to radioactive materials, and the long-term stability and leachability with respect to such materials are uncertain.

- Implementability: Thermoplastic solidification requires specialty equipment and highly trained operators to mix the wastes and solidification agent. No permits would be required for on-site treatment.

- Cost: Capital costs include specialized equipment, specialized reagents, trained operators, and power and are considered high. O&M costs include long-term monitoring and maintenance of stabilized materials and are considered low.

Based on the overall evaluation and the availability of more-proven methods, this option is not retained for further consideration.

Organic Polymer Stabilization

This process involves mixing contaminated soil and sediment with a polymer and catalyst to form a stable solid. In solidifying wastes with organic polymers, the waste does not have to be dried before polymerization. Any liquid associated with the waste will remain after polymerization, if not dried, and the polymer mass must often be dried before disposal. Significant amounts of residual water may have an adverse effect on the physical integrity of the polymer structure.

- Effectiveness: The long-term effectiveness of the various organic polymers is questionable. Stabilization of the contaminated soil will reduce the leachability of the COCs, but many of the polymers are biodegradable and over time could release the contained radionuclide, organic, and inorganic COCs. This shows that these solidification methods are more for ease of handling than for long-term security of the wastes. Hazardous or harmful releases may occur from catalysts, "weep" water, and fumes from the resins. Little is known about suitable waste types for some polymer solidification processes.

- Implementability: Specialized equipment, reagents, and trained operators are required for this process. No permits, except for construction permits, would be required for on-site treatment.

- Cost: Capital costs include equipment, specialized reagents, and trained operators and are considered high. O&M costs include long-term monitoring and maintenance of stabilized materials and are considered low.

Because of the overall evaluation and the availability of more proven methods, this option is not retained for further consideration.

Vitrification

The vitrification of contaminated soil is achieved in a reaction chamber in which high temperature is used to reduce toxic organic compounds to elemental gas and carbon. The inorganic contaminants are either entrained in the glass and siliceous melts or are volatilized at the temperatures they are exposed to in the reaction chamber. The advantages of vitrification over other thermal processes are the lack of oxidation products and large air emissions, and the reduced leachability of inorganic materials such as heavy metals (EPA 1992).

The reaction chamber melter is divided into an upper and lower section, both of which are refractory-lined and have separate electric heating systems. During operation, the upper section accepts the waste feed via gravity and contains gases and other products of pyrolysis. The lower section contains the molten glass and inorganics of the waste. The off-gas and particulates are drawn off by an induction fan and treated through a cyclone, a baghouse, and an acid gas scrubber. The molten material containing the inorganics is withdrawn from the lower section of the chamber. The process operates on a continuous cycle with the waste entering the reactor, mixing with additives (fluxes) and molten glass being withdrawn. The off-gas and vapors are treated in a gas scrubber system and released to the atmosphere. The water in the scrubber system is recycled. The concentrations of hazardous constituents and the reduction of leachability in the residuals are such that further treatment is not required (EPA 1992).

Soil containing radioactive material such as uranium can be successfully treated by vitrification. The organics in the soil would be treated by the off-gas system during pyrolysis when they become vaporized. The uranium and metals in the soil would be bonded in a glass product.

In designing the vitrification system, considerations should be given to the organic and silica content of the soil and the volume of soil to be treated. The off-gas collection system would be sized based on the amount of organics in the soil and would include HEPA filters, scrubbers, etc., to prevent any airborne radionuclides from entering the atmosphere. The ratio of silica to flux in the waste would determine the waste loading of the melter and whether any additives (flux) would be needed in the soil before melting. The amount of soil to process would also determine the size of melter needed. The off-gas systems and melters for vitrification would be commercially available through several

vendors. The melter sizes that are available range from 150-pounds-per-hour units to 100-tons-per-hour units.

The weathering behavior of volcanic glass (a natural analog to the vitrified product) can provide some measure of the long-term stability and durability of the vitrified product. Only very thin weathering rinds develop on volcanic glass over a period of several million years. The slowness in the overall degradation of a glass grain suggests that the diffusion coefficient or leachability index would remain relatively unchanged over time. Data on the long-term stability of vitrified material are not available, and the life expectancy of the vitrified product is difficult to estimate from short-term leach rates. On the basis of the longevity of volcanic glass and diffusion calculations, the vitrified product would be expected to withstand environmental exposure for thousands of years.

- Effectiveness: The effectiveness of this process varies depending on the types of radionuclides and other chemical constituents in the contaminated material. It has been developed specifically for applications to radioactive waste sites, particularly by the DOE in its remediation programs. When compared to other waste solidification methods, vitrification offers the greatest degree of containment. Vitrification of contaminated soil will reduce the leachability of the primary radionuclide and inorganic COCs, including uranium, thorium, and radium isotopes and arsenic. The primary organic COCs are PAHs (e.g., benzo(a)anthracene, chrysene, and benzo(a)pyrene) that will be released as an off-gas during vitrification and will require collection and treatment. A treatability study will be required to determine the process parameters. The volume of waste is reduced after vitrification. The collection and treatment of off-gases is an important technical consideration.

- Implementability: Most techniques for this process are not commercially available but can be made available for DOE sites, because much of the research and development were conducted in support of DOE programs. Highly trained operators would be required. Approval for air emissions may not be required because this is not an incinerator.

- Cost: Capital costs are expected to be moderate to high. Because soil will vitrify at relatively low temperatures, utility costs will be moderate; however, equipment costs will be high. Long-term monitoring of vitrified waste placement areas may be required, but O&M costs are considered low.

Vitrification is a potentially viable process which will be used as a support option in the treatment of smaller quantities of soil, sediment, or waste treatment residuals. A small, 20-ton-per-day vitrification unit will be employed to clean the wastes in the K-65 silos as part of the Operable Unit 4 remedial action plan. Once the K-65 silo wastes are cleaned up, in approximately three years, this vitrification unit may be used to process a very limited amount of treatment residuals or heavily contaminated soil or sediment from Operable Unit 5, but would not have nearly enough capacity at 20

tons per day to handle the two to three million tons of soil which would potentially need to be remediated in Operable Unit 5.

M.5.5.4 Thermal Treatment Technologies

Process options that passed the initial screening for this technology type include:

- Thermal desorption
- Rotary kiln incineration
- Fluidized bed combustion
- Circulating bed combustion
- Infrared incineration
- Plasma centrifugal furnace.

Thermal Desorption

Thermal desorption is the process by which organic contamination is removed from soil by raising the temperature of the soil to cause volatilization of the specific organic chemicals. The vapor phase is then captured and treated by carbon adsorption, concentrated, or destroyed by incineration. The concentrated organics or spent carbon would be shipped off site for disposal. This thermal treatment process would be used to treat soil contaminated with RCRA waste constituents (i.e., solvent wastes), and/or other organics such as semivolatiles and PCBs.

- Effectiveness: This process is able to remove volatile and semivolatile organic contaminants. The primary organic COCs which pose the greatest threat are PAHs (e.g., benzo(a)anthracene, chrysene, and benzo(a)pyrene), which will be removed by this process. Additionally, volatile organics and PCBs are present in the soil. This process is not capable of treating the inorganic or radionuclide COCs. This process is therefore only effective in achieving the RAOs for some of the organic contamination and applicable only as a pretreatment.

- Implementability: This technology is widely available. Specialized equipment and trained personnel would be required, but it is technically and administratively feasible. Mobile units are available.

- Cost: Capital costs for equipment, labor and utilities are considered high. O&M costs include long-term maintenance and monitoring of the final disposal area and are considered to be low.

Thermal desorption can be an effective means to remove specific organics and has been selected as the representative thermal treatment support process option for the pretreatment of certain organics in soil, sediment and treatment process residuals.

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Rotary Kiln Incineration

Rotary kiln incinerators are slightly inclined, refractory-lined cylinders. Their primary use is the combustion of organic solids. This thermal treatment process would be used to treat soil contaminated with RCRA waste constituents (i.e., solvent wastes) and/or other organics such as semi-volatiles and PCBs. Wastes are injected into the kiln at the higher end and are passed through the combustion zone as the kiln rotates. The rotation creates turbulence and improves combustion. Most rotary kilns are equipped with afterburners to ensure complete combustion. Waste retention time can vary from several minutes to an hour or more depending on the contamination, moisture content, and British thermal unit (Btu) value in the soil. Wastes are substantially oxidized to gases and inert ash within this zone. Ash is removed at the lower end of the kiln. Flue gases are passed through a secondary combustion chamber and then through air pollution control units for particulate and acid gas removal.

Rotary kilns are separated into three sizes. The small rotary kiln generally operates below 20 million Btu/hour with a capacity of 1 to 2 tons/hour, and is applicable for projects less than 5000 tons containing both volatile and semivolatile organics. The medium-sized rotary kiln generally operates in the range of 20 to 40 million Btu/hour with a capacity from about 4 to 7 tons/hour. Typical project size is from 5000 to 30,000 tons and can handle many different types of wastes with only a minimum amount of pretreatment feed-size reduction. The large rotary kiln generally operates above 40 million Btu/hour with a capacity of more than 10 tons/hour, and is cost effective only on projects requiring greater than 20,000 tons of soil to be processed. Rotary kiln incinerators are used extensively on hazardous waste projects.

- Effectiveness: Rotary kilns are capable of burning a wide range of waste in any physical form (solid, liquid, gas). The organic COCs which are volatile organics, PCBs, and PAHs will be removed by this process, but the inorganic and radionuclide COCs are not. This process, therefore, is not effective in reducing the toxicity, mobility, or volume of these COCs, but often can be used as an effective pretreatment for the removal of organics. It is also effective in both the short term (during construction and implementation) and the long term.

- Implementability: Rotary kiln incinerators, both fixed and mobile, are widely available commercially from many vendors and are in broad use for most hazardous waste applications, including RCRA, CERCLA, and other toxic substances. Specialized equipment and skilled labor are required. Some pretreatment and careful maintenance is required. The process has been found to be technically and administratively feasible.

- Cost: Capital costs for equipment, labor and utilities are considered high. O&M costs include long-term maintenance and monitoring of the final disposal area and are considered to be low.

Rotary kilns are an established and effective means of destroying organic contamination and therefore can be used as a pretreatment process option. This technology will be retained as a potential support process for the treatment of organics in soil, sediment and treatment process residuals.

Fluidized Bed Combustion

The fluidized bed system is an efficient combustion process which can operate at lower temperatures than most combustion devices because of the high-mixing energies aiding the combustion process. The most typical wastes treated in fluidized beds include slurries and sludges as well as halogenated and nonhalogenated solids. This thermal treatment process would be used to treat soil contaminated with RCRA waste constituents (i.e., solvent wastes) and/or other organics such as semivolatiles and PCBs.

The fluidized bed incinerator consists of a refractory-lined vessel containing a bed of inert granular material. The waste is injected directly into the bed or at its surface. Combustion air is forced upward through the bed, which fluidizes the material at a minimum critical velocity. A combustion environment that resists temperature fluctuations and enables the retention time to be controlled is established. Combustion gases are drawn out and treated for removal of acid gas and particulate constituents. The standard temperature operating range is from 850°F to 2100°F.

- Effectiveness: This process is well suited for incineration of high-moisture wastes such as municipal wastewater treatment plant sludges and only limited data exists on the use of fluidized beds for hazardous waste incineration. This process will destroy the organic COCs which are volatiles, PCBs, and PAHs, but will not treat the radionuclide and inorganic COCs. This process has a relatively low throughput capacity, and it is difficult to handle the residues and ash produced in the bed. Although it is effective in achieving the remediation goal for organics it still does not handle inorganics or radionuclides and its short-term effectiveness for this application is unsure.

- Implementability: This technology is used widely in the pulp and paper industry, but limited information is available for environmental applications. Equipment would have to be special ordered and require trained personnel to operate the equipment. This technology is technically and administratively feasible.

- Cost: Capital costs for equipment and utilities are considered high. Low O&M costs are associated with the disposal of the by-products of this process are considered to be low.

Because this technology does not have the track record that other thermal technologies have in treating hazardous wastes, this process option will not be retained for further consideration as a pretreatment option.

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Circulating Bed Combustion

The circulating bed combustor (CBC) system is an efficient process that can operate at lower temperatures than most combustion devices because of the high mixing energies aiding the combustion process. This thermal treatment process would be used to treat soil contaminated with RCRA waste constituents (i.e., solvent wastes) and/or other organics such as semivolatiles and PCBs. The CBC system operates in the same manner as the fluidized bed, except that the system operates at higher air velocities which allow it to operate at lower temperatures. The CBC consists of a refractory-lined vessel containing a bed of inert, granular material. The waste is injected directly into the bed. Combustion air is forced upward through the bed. A combustion environment that resists temperature fluctuations is established. Combustion gases are drawn out and treated for removal of acid gas and particulate constituents. The standard operating temperature is approximately 850°F.

- Effectiveness: This process is well suited for incineration of high-moisture soil and wastes with low Btu values. Limited data exists on the use for hazardous waste application. This process will remove the organic COCs but will not treat the radionuclide and inorganic COCs. This process is therefore only effective as a pretreatment to remove the organic contamination. It is effective in the short and long term, but only for organics.

- Implementability: Circulating fluidized bed incinerators are relatively new developments that have not been widely used for waste incineration. Equipment would have to be special ordered and require highly trained personnel to operate the equipment. This technology is technically and administratively feasible, but has not been widely implemented.

- Cost: Capital costs for equipment, labor, and utilities are considered high. This technology is more fuel efficient than the rotary kiln for low-Btu soil. The O&M costs associated with the process include long-term maintenance and monitoring of the final disposal area and are considered to be low.

Because this technology does not have the track record that other thermal technologies have in treating hazardous wastes, this process option will not be retained for further consideration as a pre-treatment option.

Infrared Incineration

Infrared incineration treats waste by passing material through the primary chamber on a belt exposed to thermal radiation. After the primary chamber, combustion products flow into a secondary chamber, which can be either a combination gas-fired/infrared unit or a conventional gas-fired secondary chamber. Flue gas treatment is accomplished by any conventional off-gas cleanup system. The unit has a soil capacity of about 3 tons/hour. The operating range is around 1400°F for the primary chamber and 1600°F for the secondary chamber. The organics are removed in the primary chamber and destroyed in the secondary chamber. This thermal treatment process would be used to

treat soil contaminated with RCRA waste constituents (i.e., solvent wastes) and/or other organics such as semivolatiles and PCBs. The residuals from this process, like the other thermal treatment processes, are ash, scrubber water, and off-gases.

- Effectiveness: Infrared units require a uniform feed and are most applicable to low-Btu soil. The organic COCs (volatile organics, PCBs, and PAHs) will be removed by this process, but the inorganic and radionuclide COCs are not treated by this process. These units are therefore effective only as a pretreatment for organics.

- Implementability: Commercial use of the infrared technology has been employed; treatment of CERCLA wastes containing halogenated and nonhalogenated organics has been completed. Specialized equipment and personnel are required to operate this system. This technology is technically and administratively feasible; mobile units are available.

- Cost: Capital costs for equipment, labor, and utilities are considered high. Low O&M costs associated with this process include long-term maintenance and monitoring of the final disposal and are considered to be low.

Infrared incineration ia applicable to site soil, sediment and treatment process residuals, and will be retained for consideration as a potential organics pretreatment support process option.

Plasma Centrifugal Furnace

The plasma centrifugal furnace is a thermal treatment process that uses the heat from a plasma torch to create a molten bath to decontaminate soil. Organic contaminants are vaporized and react at very high temperature to form harmless products. Solids melt and are incorporated into the molten bath. Metals are retained within the molten bath that, when cooled, results in a solid nonleachable matrix. This process is most appropriate for soil contaminated with metals and hard-to-destroy organic compounds, and for highly concentrated waste. It is effective for almost any toxic material, but because of the electric power required, it is most beneficial for wastes with a high solids content containing heavy metals and/or organics. Mixed hazardous and radioactive waste can also be effectively treated using this process.

- Effectiveness: This process is most appropriate for soil contaminated with heavy metals and organic compounds. Mixed radioactive waste can also be processed. This process degrades or destroys the organic COCs and immobilizes inorganic and radionuclide COCs in the resulting matrix formed in the high-temperature reactor. Potential risks to human health and the environment are present if off-gas emissions are not treated properly. This process is effective in achieving the remediation objectives and effective in the long and short terms. It is most appropriate for highly concentrated wastes.

- Implementability: The plasma centrifugal furnace process is still in the research and development stage. Specialized equipment and skilled workers are required. Problems

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have been encountered with the short electrode life and volatilization of metals. Technically, feasibility is pending and no information exists on application reliability.

- Cost: Capital costs for equipment, labor, and utilities are considered high. O&M costs include maintenance and monitoring of the final disposal area and are considered to be low.

Due to implementability concerns, this process option is not retained for further consideration in the development of remedial alternatives.

M.5.6 STORAGE

The storage of site waste and/or contaminated materials generated during remedial activities would be performed at an intermediate storage facility.

M.5.6.1 Intermediate Storage Technologies

The only process option evaluated under the intermediate storage technology is a central storage facility (CSF).

Central Storage Facility

This option would provide storage capacity at a central location pending final disposition of the waste. The central storage facility will store contaminated bulk soil, bulk hazardous debris, and containerized hazardous material. It would be an unheated tension support structure on a concrete pad with secondary containment and would have forced ventilation equipment to remove vehicle fumes from inside the facility. A sump/drain system would also be included to collect water that may leach from stored materials which would be segregated in the storage facility according to type of contamination. It is anticipated that storage capacity should be several thousand cubic yards for bulk soil plus several thousand square feet for bulk hazardous debris and containerized material.

- Effectiveness: This option is effective in isolating contaminated soil, sediment and debris so that it would not pose potential threats to human health and the environment. A CSF would provide only a temporary storage before permanent disposal of chemically and radioactively contaminated soil and sediment. Effectiveness is dependent on continued maintenance of the facility.

- Implementability: The design and construction of a storage facility is readily implementable. Equipment and skilled workers are available. A permit would not be required for an on-site facility; however, regulatory agencies would retain approval authority for siting of a storage facility.

- Cost: The capital cost of constructing such a facility would be considered moderate. The O&M requirements include monitoring, maintenance, and security measures and are also considered to be moderate.

Construction of a CSF will be retained for further consideration as a support to other excavation and disposal options.

M.5.7 DISPOSAL

The technologies considered for the disposal of soil and sediment include waste transportation, on-property disposal and off-site disposal.

M.5.7.1 On-Property Disposal Technologies

The process options evaluated under on-property disposal for this technology include:

- Backfilling
- Consolidation
- Engineered disposal cell.

Backfilling

This option involves the backfilling of on-property excavations with clean or slightly contaminated soil, sediment or debris. The material could be backfilled with no other actions or monitoring required, as long as the contaminant levels in the material satisfy remediation goals. If such goals are not met, it could be possible to supplement this option with containment and monitoring to ensure protection of human health and the environment.

- Effectiveness: On-property backfilling cannot be used unless the radionuclide, organic, and inorganic COCs meet the remediation goals for soil. If the contaminant concentrations in the backfilled materials attain the remediation goals, then backfilling would be highly effective. If remediation goals are not attained, backfilling could be supplemented with other actions, such as containment, monitoring, stabilization and/or institutional actions.

- Implementability: Equipment, labor, and on-property disposal sites are readily available. Permits would not be required.

- Cost: Capital costs would include costs for standard earthmoving and handling equipment and are considered low. There are low O&M costs associated with this option.

Backfilling of on-property excavations with site soil, sediment and debris is retained for incorporation into remedial action alternatives as a primary representative process option.

Engineered Disposal Cell

This option involves construction of an on-property engineered disposal cell for disposal of site soil and sediment, nonrecoverable debris, and treatment process residuals.

- Effectiveness: An on-property engineered disposal cell would be effective in isolating contaminated material so that direct contact threats and the potential for contaminant migration are reduced. It would be necessary to determine whether the primary radionuclide and inorganic COCs, including uranium, thorium, and radium isotopes and arsenic pass waste acceptance criteria requirements. The primary organic COCs (e.g., benzo(a)anthracene, chrysene, and benzo(a)pyrene) are relatively immobile and primarily present risks from direct contact. It would therefore be necessary to prevent direct contact or determine that the material satisfies waste acceptance criteria requirements. An on-property disposal cell would be a permanent solution for disposal of contaminated material. The effectiveness is dependent on the continued maintenance and permanence of the facility.

- Implementability: Disposal cell design and construction are widely practiced techniques. Permits would not be required for an on-property disposal cell; however, regulatory agencies would retain approval authority for facility siting. Site conditions and land limitations may pose problems.

- Cost: The capital cost of constructing an on-property disposal cell is considered high. The cost is dependent on the volume of material to be placed in the cell. A engineered disposal cell would require inspections, monitoring, maintenance, security measures, and institutional controls for the life of the facility. O&M costs are considered moderate.

An engineered disposal cell, which is applicable to site soil, sediment, nonrecoverable debris and treatment process residuals, would be effective and implementable and is retained for incorporation into remedial action alternatives as a primary representative process option.

Consolidation

This option involves the consolidation of slightly contaminated soil and sediment at a central location at the FEMP site. The intent of consolidation is to remove contaminated material from portions of the FEMP property to allow for alternative uses. It may be necessary to supplement this option with containment and/or monitoring to ensure protection of human health and the environment.

- Effectiveness: The effectiveness of consolidation depends on the contaminant concentrations in the material being consolidated. The primary COCs include arsenic, uranium, thorium, radium, and PAHs. If the concentration exceeds the waste acceptance criteria, consolidation could be supplemented with other actions such as containment, monitoring, and/or institutional controls. It is effective for freeing portions of the FEMP property for alternate uses.

- Implementability: Equipment and labor are readily available. Permits would not be required. Regulatory barriers to this process option may exist due to the location of the FEMP site over a sole-source aquifer.

- Cost: Capital costs would include costs for standard earthmoving and handling equipment and are considered low. O&M costs could include monitoring and are also considered low.

On-property consolidation of slightly contaminated soil and sediment is retained for incorporation into remedial alternatives as a primary representative process option.

M.5.7.2 Off-Site Disposal Technologies

Process options being evaluated for the off-site disposal technology include:

- The Nevada Test Site
- Permitted commercial facility.

Nevada Test Site (NTS)

This option involves the disposal of wastes at an existing DOE facility. NTS is located in Nye County, Nevada, with the southeast corner lying about 65 miles northwest of Las Vegas. The NTS encompasses about 1350 square miles. NTS has an arid climate and is surrounded on the east, north, and west sides by public access exclusion areas which provide a buffer zone between the test areas and public lands. Depths to groundwater beneath the NTS vary from about 500 feet to greater than 2000 feet. An Environmental Impact Statement for waste disposal activities at the NTS is currently being prepared to satisfy the requirements of the National Environmental Policy Act.

Low-level contaminated soil and sediment, solid residuals from waste treatment processes, or unrecoverable debris could be transported for permanent disposal at the NTS. As a condition of disposal at NTS, no untreated wet, raw waste or free liquids are accepted. An additional NTS requirement is that the waste can be characterized only as a low-level radioactive waste. The site cannot accept mixed (hazardous and radioactive) waste at this time; however, a permit to accept mixed waste is pending. In addition, the waste cannot contain PCBs at concentrations above 50 parts per million (ppm) and all wastes shipped to the NTS must be containerized; no bulk material will be accepted. Radioactive waste from the FEMP is currently being shipped to NTS. Waste transport to the NTS would be by truck as there is no rail line directly to the disposal site.

- Effectiveness: The NTS would effectively isolate the waste materials from potential receptors. The primary radionuclide COCs which would require the soil to be disposed of in a low-level disposal facility are uranium, thorium, and radium. Primary organic and inorganic COCs on-site are PAHs and arsenic, respectively. This facility can accept all soil, sediment and waste treatment process residuals from Operable Unit 5 except those classified as mixed waste or that contain more than 50 ppm of PCBs.

- Implementability: Appendix E discusses waste acceptance criteria and the disposal sites' ability to meet them. Logistical implementation would be moderately difficult due to

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the distance from the FEMP site. As no rail transportation is available into the site, shipment by truck or rail/truck combination would be required. Administratively, however, this process option is readily implementable since the FEMP site has an approved NTS waste shipment and certification program already in place.

- Cost: The capital cost for waste disposal at NTS is considered high and would include packaging costs in addition to the disposal fees. There would be no O&M costs associated with this option after completion of remedial activities.

Off-site disposal at NTS would be effective and implementable and is retained for incorporation into remedial alternatives as a primary process option.

Commercial Disposal Facility

The Envirocare commercial disposal facility evaluated is representative of a typical permitted commercial disposal site. It is licensed by the State of Utah for naturally occurring radioactive material (NORM), low-activity radioactive waste, mixed NORM, and chemically hazardous waste. The facility license restricts the quantities of waste that can be actively processed at one time, maximum quantities of special nuclear material that may be handled, and maximum concentration of mixtures of radionuclides that may be present in each waste stream. Hazardous wastes that can be accepted at the facility include D-characteristic wastes, and most F-, P-, U-, and K-listed wastes. F-listed dioxin wastes cannot be accepted at the facility. The facility can receive wastes in bulk shipments.

The site is located on the eastern edge of the Great Salt Lake Desert in Toole County, Utah, approximately 81 miles west of Salt Lake City. The site occupies approximately 540 acres in an area zoned for radioactive waste disposal and is located approximately 1 mile south of a railroad switch point identified as Clive. Much of the land surrounding the site is public domain administered by the U.S. Bureau of Land Management.

The site is situated in an arid desert rated by the Bureau of Land Management as poor for grazing or forage production. Vegetation at the site is a homogeneous, semidesert low shrubland, composed primarily of shadescale. No wetlands or other aquatic habitats are present at or in the vicinity of the disposal facility. The nearest stream channel ends approximately 1.9 miles east of the site, and the nearest body of permanent surface water is located about 28 miles east of the facility.

- Effectiveness: An operating permitted commercial disposal site would be effective for isolation of the waste materials from potential receptors. The primary radionuclide COCs which require the soil to be disposed of in a low-level disposal facility are uranium, thorium, and radium. Primary organic and inorganic COCs are PAHs and arsenic. The representative site is located near Clive, Utah, an arid western location isolated from the aquifer and nearby population. This facility can accept all

contaminated soil, sediment, waste treatment residuals, and nonrecoverable debris from Operable Unit 5.

- Implementability: Similar to the NTS process option, this facility is a relatively long distance from the FEMP site; however, shipment by rail alone is possible in transporting wastes to the commercial site. Low-specific-activity waste designated for this site does not require containerization and can be shipped in bulk using rail transportation. To ship waste to this facility, a new waste certification program would need to be developed and implemented to assure compliance with the disposal facility's waste acceptance criteria. This waste certification program, discussed in Appendix E, would be moderately difficult to implement.

- Cost: The capital cost of implementation for disposal would be high because of the quantity of waste requiring disposal. However, the costs may be lower than those required for NTS because containerization of the contaminated soil is not required. There would be no O&M costs after completion of the remediation.

Off-site disposal at a permitted commercial facility such as Envirocare or an equivalent facility would be effective and implementable and is retained for incorporation into remedial alternatives as a primary process option.

Selection of a Representative Disposal Process Option

For purposes of this FS, it is assumed that the commercial disposal facility that can accept both low-level radioactive and mixed wastes will be used for off-site disposal and will be selected as the representative process option.

M.5.7.3 Waste Transportation Technologies

The process options evaluated under waste transportation include:

- Truck transport
- Rail transport.

Truck Transport

Truck transport can easily offer portal-to-portal service with the road system available at the FEMP site. The primary disadvantages with this process option are the size, relatively undeveloped nature, and heavy traffic patterns related to the roads near the FEMP site, and the higher cost to the public as compared to rail transport.

- Effectiveness: Truck transport is effective for short distances, but is not as effective as rail transport for the distances required for the off-site disposal option at NTS or other facilities, depending on the availability of rail spurs. Truck transportation is a highly reliable means of transporting contaminated material. Truck transport would be required for on-property disposal and off-site disposal to facilities without rail spurs.

Potential exposures caused by accidents could be reduced by placing the transported wastes into containers.

- Implementability: Truck transport would be moderately difficult to implement due to the large volumes of waste and the long distances involved for off-site disposal. Implementation would be relatively easy with regard to on-property disposal options. Truck transport would require full compliance with all applicable Department of Transportation (DOT) regulations. Notification to state and local agencies along the transport route would be required.

- Cost: Capital costs for truck transportation, which includes construction of access roads, are considered to be moderate, while O&M cost, which includes trucking fees, and maintenance of the access roads and loading areas, would also be moderate.

The option of using truck transportation is being retained for further consideration as a support action with on-property and off-site disposal options. It has been selected as a representative process option.

Rail Transport

The FEMP site can readily support rail transportation by using existing on-site rail spurs. Some off-site disposal options have facilities with the capability of receiving the waste by rail. Transportation to NTS may require a combination of truck and rail transport. Contaminated material shipped by rail to NTS would go through the Las Vegas, Nevada terminal. In cases where exclusive-use shipments are required, the contaminated material would be placed within a container that would be placed on a flat-bed rail car. At the Las Vegas terminal, the container would be removed from the train without losing exclusive-use status and placed on flat-bed trucks where they would be transported to NTS. The Las Vegas Terminal is a new facility which has been constructed to handle the transfer of hazardous materials, including radioactive material for the NTS. Truck transportation would not be required for shipment to the permitted commercial disposal site. Although rail transport has a lower percentage of accidents per trip, the volume of material hauled per trip is many times higher.

- Effectiveness: Rail transportation is effective for transportation of contaminated material to off-site disposal facilities with railroad spurs and to NTS. Rail transport would be applicable to off-site disposal options at facilities with rail spurs and in combination with truck transport for disposal at NTS. Rail transportation allows large volumes of contaminated material to be transported at one time. Rail transport is highly reliable. Typically, fewer accidents occur on a per-trip basis by rail than by truck. However, should an accident occur, the public could be exposed to much larger quantities of contaminated material. Exposures could be reduced by the containerization of the transported wastes.

- Implementability: Rail transport is readily implementable because the FEMP site has an existing on-site rail spur. However, rail transport is susceptible to route availability and

coordination with state and local agencies along the route, and would require full compliance with all applicable DOT regulations. In addition, some rail upgrades may be required.

- Cost: Capital costs for rail transportation, which include upgrading of the on-site rail spur and the loading areas is considered to be high. O&M costs, which include rail fees, would be low.

The option of using rail transportation has been retained for further consideration as a support action to off-site disposal options, and has been selected as a representative process option.

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Appendices H through M

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