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FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

APRIL 29, 1994

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

DRAFT

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REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

Attachment to Operable Unit 1 Feasibility Study Report
Appendix I to Operable Unit 2 Feasibility Study Report

APRIL 29, 1994

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

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ACRONYMS

AAQS	Ambient Air Quality Standards
ARAR	applicable, relevant, and appropriate requirements
ASI	American Standards Institute
BEIR	biological effects of ionizing radiation
BGS	below ground surface
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/s	centimeter per second
cm/yr	centimeter per year
COC	contaminant of concern
CRARE	Comprehensive Response Action Risk Evaluation
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ECAO	U.S. Environmental Criteria and Assessment Office
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EPA	Environmental Protection Agency
ERA	ecological risk assessment
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Co.
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
FRG	final remedial goal
FS	feasibility study
FS/RA	feasibility study/risk assessment
GI	gastrointestinal
GMA	Great Miami Aquifer
GMR	Great Miami River
HDPE	high density polyethylene
HEAST	Health Effects Assessment Summary Tables
HEC-1	U.S. Army Corps of Engineers Hydrologic Engineering Center
HELP	Hydraulic Evaluation of Landfill Performance
HI	hazard index
HQ	hazard quotient
IAWWT	interim advanced waste water treatment
ICRP	International Commission of Radiological Production
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
ISCLT2	Industrial Source Complex Dispersion Model, Long-Term, Version 2
K_d	solid-liquid partitioning coefficient
kg	kilogram
KPH	kilometers per hour
LC/DS	leachate collection/detection system
LET	linear energy transfer
LOAEL	lowest observed adverse effect level

LRA	leading remedial alternative
MAGLC	maximum allowable ground level concentration
MAV	mass-weighted average
MCL	maximum concentration level
MCLG	maximum concentration level goal
mg	milligram
mph	miles per hour
mrem	millirem
MSL	mean sea level
MUSLE	Modified Universal Soil Loss Equation
NCP	National Contingency Plan
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NOAEL	no observed adverse effect level
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
NWS	News Weather Service
ODAST	One-Dimensional Analytical Solute Transport
OEPA	Ohio Environmental Protection Agency
ORP	Office of Radiation Program
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
pCi/g	picocurie per gram
pCi/l	picocurie per liter
ppm	parts per million
PRA	preferred remedial alternative
PRG	preliminary remedial goal
PRL	proposed remediation level
QA	quality assurance
RA	risk assessment
RAGS	Risk Assessment Guidelines for Superfund
RAWPA	Risk Assessment Work Plan Addendum
RCRA	Resource Conservation and Recovery Act
RDA	recommended daily allowance
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RIQO	risk information quality objective
RME	reasonable maximum exposure
ROD	record of decision
SARA	Superfund Amendment and Reauthorization Act
SOWC	Southern Ohio Water Company
SSOD	storm sewer outfall ditch
SWCR	Site-Wide Characterization Report

ACRONYMS
(Continued)

SWF&IM	Surface Water Flow and Infiltration Model
TBC	to be considered
TCLP	toxicity characteristic leaching procedure
TEF	toxicity equivalency factor
TFV	threshold fraction value
TSP	total suspended particulate
TWA	time-weighted average
UCL	upper confidence limit
UMTRA	Uranium Mill Tailings Remedial Action
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USDA	United States Department of Agriculture
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
VOC	volatile organic compound
VS2DT	Variability Saturated 2-Dimentional Transport

ENGLISH/METRIC AND METRIC/ENGLISH EQUIVALENTS.

In this document, units of measure are presented With the metric unit first, followed by the English equivalent in parentheses. In Tables, the data are generally in English or metric units only. The following table lists the appropriate equivalents for English and metric units.

English/Metric Equivalents

Multiply	By	To Obtain
acres	0.4047	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
degrees Fahrenheit (°F) -32	0.5555	degrees Celsius (°C)
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (l)
gallons (gal)	0.003785	cubic meters (m^3)
inches (in.)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
pounds (lb)	0.4536	kilograms (kg)
short tons (tons)	907.2	kilograms (kg)
short tons (tons)	0.9072	metric tons (t)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
yards (yd)	0.9144	meters (m)

Metric/English Equivalents

Multiply	By	To Obtain
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
cubic meters (m^3)	264.2	gallons (gal)
degrees Celsius (°C) + 17.78	1.8	degrees Fahrenheit (°F)
hectares (ha)	2.471	acres
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	short tons (tons)
kilometers (km)	0.6214	miles (mi)
liters (l)	0.2642	gallons (gal)
meters (m)	3.281	feet (ft)
meters (m)	1.094	yards (yd)
metric tons (t)	1.102	short tons (tons)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)

EXPOSURE ASSESSMENT SYMBOLS

Inhalation of Dusts, Volatiles, and Radon

I_a = Intake from inhalation (pCi) or (mg/kg/day)
C_a = Concentration in air (pCi/m^3) or (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

Ingestion of Drinking Water, Food Stuffs

I_w = Intake from drinking water (pCi) or (mg/kg/day)
C_w = Concentration in water (pCi/l) or (mg/l)
IR = Ingestion rate (l/day)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
FI = Fraction ingested from the contaminated source (unitless)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

Inhalation of Volatiles from Water While Showering

I_a = Intake from inhalation (pCi) or (mg/kg/day)
C_a = Concentration in air (pCi/m^3) or (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

Dermal Contact with Soil/Sediment and While Bathing or Swimming

AB_w = Absorbed dose from contact with water (mg/kg/day)
C_w = Concentration in water (mg/l)
SA = Skin surface area available for contact (cm^2)
PC = Dermal permeability constant (cm/hr)
ABS = Absorption factor (unitless)
AF = Skin adherence factor (mg/cm^2)
ET = Exposure time (hr/day)
ED = Exposure duration (yr)
EF = Exposure frequency (days/yr)
CF = Conversion factor (1l/1000 cm^3)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

000017

EXPOSURE ASSESSMENT SYMBOLS
(Continued)

Incidental Ingestion of Soil/Sediment and While Swimming

I_s = Intake from soil or sediment (pCi) or (mg/kg/day)
C_s = Concentration in soil or sediment (pCi/g) or (mg/kg)
IR = Ingestion rate (g/day) or (mg/day)
CF = Conversion factor 10-6 kg/mg
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/yr)
ED = Exposure duration (yr)
BW = Body weight (kg)
AT = Averaging time (days); for noncarcinogens, AT equals (ED)(365 days/yr); for carcinogens, AT equals (70-year lifetime)(365 days/yr)

External Radiation Exposure

DE = Dose equivalent (mrem)
DR = Dose equivalent rate (mrem/hr)
EF = Exposure frequency (days/yr)
ETi = Exposure time, fraction spent indoors (unitless)
ETo = Exposure time, fraction spent indoors (unitless)
ED = Exposure duration (yr)
FD = Fraction of a day
FY = Fraction of a year
SHi = Building shielding factor for dose equivalent rate reduction indoors (unitless)
SHo = Building shielding factor for dose equivalent rate reduction outdoors (unitless)

CRARE
EXECUTIVE SUMMARY

ES.1 BACKGROUND

The Fernald Environmental Management Project (FEMP) site is a federal facility where pure uranium metals were produced for DOE from 1951 to 1989. In 1991, the FEMP was officially closed as a production facility, but environmental studies, response actions, and site cleanup activities continue.

In accordance with the 1991 Amended Consent Agreement between the EPA and DOE, the FEMP was separated into five operable units, each requiring a remedial investigation and feasibility study. During each feasibility study, potential contaminants of concern are identified and cleanup levels are established to guide the remedial actions. As part of each feasibility study, a Comprehensive Response Action Risk Evaluation (CRARE) is prepared to analyze the residual human-health risks at the site after all remedial actions have been completed. The CRARE determines the risk to individual receptors from the combined sources of the five operable units. This allows all parties concerned to understand the impact of each operable unit on the site's total residual risk and provides a basis for revising cleanup levels as needed to meet EPA decision making criteria.

OPERABLE UNITS

The FEMP's five operable units and their associated structures are described below:

- Operable Unit 1:

  Waste Pits 1 through 6, the Clearwell, burn pit, berms, liners, and associated contaminated soil within the operable unit boundary. Waste Pits 3 and 5 and the Clearwell also contain water, including perched water.

- Operable Unit 2:

  The active and inactive flyash piles, South Field, lime sludge ponds, solid-waste landfill, berms, liners, and associated contaminated soil and perched water within the operable unit boundary.

- Operable Unit 3:

  The production area and associated facilities and equipment including all structures, utilities, drums, tanks, solid waste, waste product, effluent lines, K-65 transfer line, wastewater treatment facilities, fire training facilities, scrap metal piles, feed stocks, and the coal pile.

- Operable Unit 4:

  Silos 1, 2, 3, and 4, berms, decant tank system, radon treatment system, and associated contaminated soil and perched water within the operable unit boundary.

- Operable Unit 5:

  Perched and regional groundwater, surface water, soil not associated with other operable units (such as hot spots not previously identified). Also, soil and perched water beneath the Operable Unit 3.

FEMP REMEDIATION

The remedial investigations and feasibility studies at the FEMP have led to the development and implementation of numerous removal actions. As defined in the Amended Consent Agreement, removal actions abate, minimize, stabilize, mitigate, or eliminate the release or threatened release of hazardous substances, pollutants, contaminants, or hazardous constituents at or from the FEMP. In 1993, the DOE published a comprehensive survey of the FEMP site called the Site-Wide Characterization Report. This report, which includes a baseline risk assessment, provides data and risk analyses on the effects of the removal actions completed as of March 1993. Because the CRARE is a postremediation document, by definition all removal actions will have been completed well before the time periods examined in the CRARE.

REMEDIAL ALTERNATIVES

Within the CRARE, the preferred remedial alternative from each operable unit's feasibility study is evaluated. If an operable unit's feasibility study has not been completed, then the leading remedial alternative from the Site-Wide Characterization Report is used as the preferred remedial alternative. This CRARE incorporates the preferred remedial alternatives for Operable Units 1, 2, and 4 (which have been updated using the feasibility study reports for those units) and the leading remedial alternatives for Operable Units 3 and 5 (whose feasibility studies have not yet been completed). With the development of new field data and new approaches to remediation,

major changes may be expected for some of the operable unit remedial alternatives. While the remedial alternatives do not dictate what proposed remedial goals should be, they do indicate what level of cleanup the remedial technologies can possibly achieve. Changes to the Operable Unit 3 and 5 leading remedial alternatives, therefore, may result in significant changes to future CRARE transport modeling and risk assessment. The enclosed foldout illustrates the postremediation permanent disposal facilities to be constructed as projected based on the remedial alternatives presented below.

Operable Unit 1 Preferred Remedial Alternative

The preferred remedial alternative for Operable Unit 1 includes removal, drying and off-property disposal of waste pit materials, caps, liners, and contaminated soils, backfilling of excavated areas with clean soil, and construction of a cover system with an infiltration-limiting layer. Affected berms and soil beneath the pits will be removed to Operable Unit 5 for soil washing to meet proposed remedial goals, followed by on-property disposal.

Operable Unit 2 Preferred Remedial Alternative

Active Flyash Pile. Contaminated materials above cleanup levels would be consolidated into the northeastern portion of the South Field. A clay cap will be constructed over these materials and adjacent to the South Field and Inactive Flyash Pile composite cap. Subsurface, lateral groundwater drainage will be collected and treated.

Lime Sludge Ponds. The current preferred remedial alternative consists of consolidating materials contaminated above prescribed levels, which will be placed under a composite cap.

Solid-Waste Landfill. The Solid-Waste Landfill includes one area contaminated to higher levels of activity and to greater depths below ground surface than the remainder of the landfill. This has resulted in contamination of the perched water beneath the landfill. The preferred remedial alternative for the subunit involves excavation, consolidation, regrading, and a composite cap.

South Field. The South Field has been identified as a source of contamination for the Great Miami Aquifer. Soil and materials contaminated above cleanup levels would be excavated and consolidated in the northeastern portion of this Operable Unit 2 subunit. The excavated areas

would be regraded, and a composite cap would be placed over the consolidated material. The lateral drainage of perched groundwater would be collected and treated throughout the Current Land Use scenario.

Inactive Flyash Pile. The proposed remediation approach includes excavating and consolidating the material contaminated above cleanup levels. A composite cap would be constructed over the consolidated material. The excavated areas of the Inactive Flyash Pile would be backfilled with clean fill and planted with vegetation.

Operable Unit 3 Leading Remedial Alternative

For the Operable Unit 3 leading remedial alternative, contaminated material would be removed, treated and/or decontaminated, temporarily placed in storage, and finally disposed to reduce the potential for contaminant migration. Decontamination and treatment residue would require further treatment and disposal. Contaminated material would be disposed in the vaults while clean material would be free-released for reuse or recycling.

Operable Unit 4 Preferred Remedial Alternative

The preferred remedial alternative for Operable Unit 4 includes removing the waste stored in Silos 1, 2, and 3, stabilizing it via vitrification, and removing it to an off-property disposal facility. Contaminated soil and construction material from the silo berms, subsoil, and decant tank would be removed to the extent necessary to achieve risk-based proposed remedial goals and temporarily stored on-property for eventual treatment and disposal with Operable Unit 5 soils. Silo 4 would be remediated as necessary along with Silos 1, 2, and 3. Silo 4 may also be used as a demonstration site for testing Silo 1, 2, and 3 waste and silo demolition techniques.

Operable Unit 5 Leading Remedial Alternative

Under the leading remedial alternative for Operable Unit 5, contaminated groundwater would be extracted, treated at an on-property facility, and discharged to the Great Miami River through the newly constructed effluent line. Treatment residuals would be disposed in on-property disposal facilities. The leading remedial alternative also involves excavating contaminated sediment and soil necessary to meet risk-based proposed remedial goals, transporting the contaminated material to an on-property location for treatment using soil-washing, and returning the treated material as backfill. For uranium-238, the proposed remedial goal of 60 picocuries per gram was assumed, to

be consistent with the Operable Unit 4 feasibility study proposed remediation level. The remediation goals for other contaminants of concern were assumed to be the proposed remedial goals as presented in the Site-Wide Characterization Report. The soil-washing fluids would be recycled and the removed contaminants stabilized and disposed in on-property disposal facilities.

ES.2 CRARE TECHNICAL APPROACH

This Operable Unit 1&2 CRARE presents a postremediation risk evaluation for all FEMP contaminants of concern transported via the direct pathways of air, soil, groundwater, surface water, and radiation, as well as the indirect pathway of farm product consumption. The technical approach and results have been summarized by the following categories and graphically presented on the foldout:

- Site-wide sources of contamination
- Identification of contaminants of concern
- Receptor characterization
- Pathways of exposure
- Postremediation residual risk characterization
- Operable unit contribution to risk
- Impact of uncertainty on the risk estimates

SITE-WIDE SOURCES OF CONTAMINATION

The primary sources of contamination remaining after site remediation include:

- Residual foot print areas for all operable units
- Eastern Vaults
- Operable Unit 1 and 2 capped/covered areas

IDENTIFICATION OF CONTAMINANTS OF CONCERN

Potential contaminants of concern detected on-property were identified using Appendix R of the Site-Wide Characterization Report and the remedial investigation/feasibility study reports for Operable Units 1, 2, and 4. A multi-step screening process identified those contaminants of concern that would be present on FEMP property during the 70- and 1000-year postremediation time frames. These 51 contaminants are presented on the foldout.

Volatile organic compounds were eliminated from consideration as contaminants of concern because evaporation would rapidly remove these compounds from the FEMP before the time periods under evaluation. Also, remediation activities implemented before the time frame considered in the CRARE would be expected to disturb, expose and mix many of the soils containing volatiles and thereby hasten the evaporation of these contaminants. Similarly, other organic compounds were removed from consideration after evaluating their organic decay rates in water and soil.

The remaining contaminants were then used in fate and transport modeling of air, surface water, groundwater, and farm products. During the groundwater fate and transport analysis, the contaminants were further screened using preliminary modeling techniques to determine if significant quantities would reach groundwater within the 1000-year time frame. It is unlikely that any major contaminants of concern were overlooked.

LAND USE

The CRARE evaluates sources, release mechanisms, transport-media and risk pathways for various human receptors under the Current and two Future Land Use scenarios of the five operable units. The Current Land Use scenario describes the FEMP for a 70-year period starting after all remedial actions are complete. The 70-year period is based on the risk assessment work plan addendum, and is the life span of an individual. The scenario assumes DOE ownership, site access control, and maintenance of the FEMP and associated remedial structures for 70 years. The only remaining treatment facility active on the site at the start of the 70 years should be the wastewater treatment plant in Operable Unit 5.

The two Future Land Use scenarios describe the FEMP for up to 1000 years after all remedial actions are complete: Future Land Use With Federal Ownership assumes continued government ownership and land use restrictions, while Future Land Use Without Federal Ownership assumes occupation by a resident farm. Both future scenarios assume no access control, maintenance, or treatment operations. Contaminant fate and transport have been modeled for 1000 years.

RECEPTORS

The following on-property and off-property reasonable maximum exposure (RME) receptors have been evaluated in this CRARE.

On-Property	Off-Property
• Resident farm adult (who ingests water from the Great Miami Aquifer)	• Resident farm adult
• Resident farm adult (who ingests perched groundwater)	• Resident farm child
• Resident farm child	
• Expanded trespasser	
• Trespassing child	
• Groundskeeper	

These receptors represent a wide array of potential land uses. Even though the FEMP was not evaluated for residential-only land use, the use of resident farm receptors (who consume on-property farm produce) is more conservative than the use of a residential-only receptor. For the evaluation of carcinogenic risk, all adult farmers were assumed to be exposed for their entire 70-year life spans.

For reference, the ILCR is defined as the incremental lifetime cancer risk to an individual as a result of exposure to a contaminant for a 70-year lifetime. The health hazard resulting from exposure to noncarcinogenic contaminants was evaluated and expressed as the hazard index (HI). The HIs were estimated by comparing an exposure level or intake to the EPA reference dose. If the resulting HI is greater than 1, there is a concern for potential health effects.

PATHWAYS

The pathways considered in this CRARE are:

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

CONTAMINANT-RELATED POSTREMEDIATION RESIDUAL RISK

The estimated risks from the FEMP are summarized in the drawing. The detailed risk analysis indicates that the major radionuclides of concern are uranium-238, uranium-234, technicium-99, thorium-228, radon-222, radium-228, and lead-210. The principal contributors to the chemical carcinogenic risk are arsenic, beryllium, chromium, and the PCBs. The principal contributors to the noncarcinogenic hazards are antimony, arsenic, boron, cobalt, manganese, mercury, molybdenum, silver, and zinc.

OPERABLE UNIT CONTRIBUTIONS TO RISK

Based on a review of risk estimations for the RME receptors and the three land use scenarios, it is evident that the combined contribution to total risk from Operable Units 1, 2, 3, and 4 ranges from 1 to 10 percent. Operable Unit 5 contributes from 90 to 99 percent of total risk.

UNCERTAINTIES

The preparation of this Operable Unit 1&2 CRARE employed conservative assumptions and the best scientific and engineering judgement consistent with the EPA guidance. The risk principles and equations found in the FEMP Risk Assessment Work Plan Addendum were used throughout this analysis, as were the exposure parameters from the Operable Unit 2 Remedial Investigation Report. Results of the CRARE have identified points of departure from target risk ranges for ILCRs as discussed in the National Contingency Plan (which translates to carcinogenic risk beyond the range of 10^{-4} to 10^{-6}) and from the benchmark HI of 1 discussed in the EPA Risk Assessment Guidance for Superfund.

ES.3 SUMMARY AND CONCLUSIONS

Potential health hazards and risks to on-property and off-property receptors were quantified and evaluated in this Operable Unit 1&2 CRARE. *The conclusion reached by applying the CRARE process is that the FEMP would appear to be unsuitable as a family farm even after remediation is complete.* The foldout is a comprehensive summary of the CRARE process and includes risk results for each receptor by land use. For this CRARE, the major pathways of concern were found to be the inhalation of fugitive particulates, the consumption of drinking water, and dermal contact with soils. External radiation was a significant pathway of concern for all on-property receptors.

The carcinogenic risk estimate for the on-property resident farmer is the most-elevated and exceeded the target risk range. The ingestion of perched ground-water would increase the ILCR by about 100 percent for this receptor. Risks for the trespassing child and expanded trespasser are within the target risk range for both carcinogenic and noncarcinogenic effects.

The risks for the groundskeeper are above the target range for both carcinogenic and noncarcinogenic health effects. The carcinogenic risks for the off-property farmer are above 10^{-4} for all adult exposure scenarios. The noncarcinogenic HI causes the most concern for the farm child.

A review of the estimated carcinogenic risks and noncarcinogenic hazards follows.

Current Land Use

- Carcinogenic Risk:

  The groundskeeper and off-property resident farm adult have ILCRs beyond the target range of 10^{-4} to 10^{-6}. The trespassing child has an ILCR within the target range.

- Noncarcinogenic Hazard:

  The groundskeeper and both the off-property resident farm adult and child have HIs above 1.

Future Land Use With Federal Ownership

- Carcinogenic Risk:

  The trespassing child and the expanded trespasser have estimated ILCRs of less than 10^{-4}. The off-property resident farm adult has an estimated ILCR greater than 10^{-4}.

- Noncarcinogenic Hazard:

  The off-property resident farm adult and child both have estimated HIs above 1.

Future Land Use Without Federal Ownership

- Carcinogenic Risk:

  The on-property receptors have ILCRs above the target range of 10^{-4} to 10^{-6}. The off-property adult receptor has an ILCR above 10^{-4}.

- Noncarcinogenic Hazard:

  All on- and off-property receptors have HIs above 1.

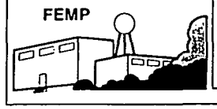
ES.4 RECOMMENDATIONS

Because the majority of the FEMP residual risk is associated with Operable Unit 5 soils, future CRAREs should focus on refining and completing information on this unit. Further research should be conducted on refining groundwater modeling parameters that apply to specific operable units or the FEMP as a whole. Bench-scale testing of how remediated soil conditions will change may be warranted. Additionally, investigations should be conducted into the physical characteristics of the remediated soils and into developing an appropriate fugitive particulate emission model for long-term risk analysis.

COMPREHENSIVE RESPONSE ACTION RISK EVALUATION - DOE FERNALD REMEDIATION

5506

COLLECT AND EVALUATE DATA



The Fernald Environmental Management Project (FEMP) site is a federal facility where uranium metals were produced for DOE from 1951 to 1989. In 1991, the FEMP was closed as a production facility, but environmental studies, response actions and site cleanup activities continue.

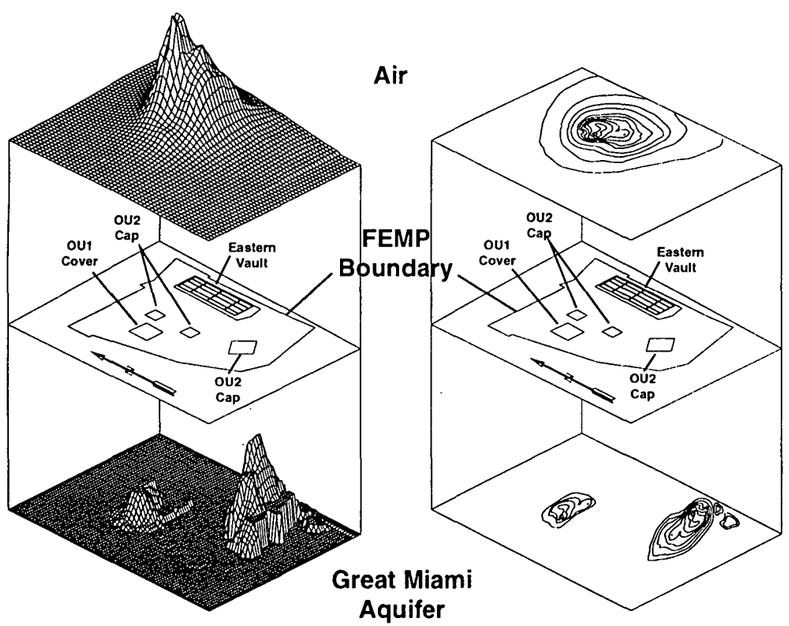
SWCR (Site-Wide Characterization Report) + RAWPA (Risk Assessment Work Plan Addendum) + OU4 RI/FS (Remedial Investigation/ Feasibility Study) + OU1 RI/FS (Remedial Investigation/ Feasibility Study) + OU2 RI/FS (Remedial Investigation/ Feasibility Study) + EPA Comments on OU4 CRARE

IDENTIFY CONTAMINANTS OF CONCERN

SWCR Appendix R – RI/FS Screening OU1, 2, 4 – Remove Volatile Organics Over Time – Organic Degradation – Pump and Treat Removes Semivolatiles

ASSESS EXPOSURE

U-238 Modeled Concentrations in 3-D and 2-D Isopleths



Computer Modeling:
Air Particulates
Air-Radon
Groundwater
Surface Water
Radiation

BACKGROUND

In accordance with the 1991 Amended Consent Agreement between the US EPA and DOE, a Comprehensive Response Action Risk Evaluation (CRARE) will be prepared for each operable unit at the FEMP site. The CRAREs are to analyze the residual human-health risks projected to remain on-site following the implementation of the remedial actions for the five operable units.

This Operable Unit 1&2 CRARE presents a postremediation risk evaluation for all FEMP contaminants of concern transported via the direct pathways of air, soil, groundwater, surface water and radiation, as well as the indirect pathway of farm product consumption.

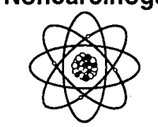
SUMMARY OF HEALTH RISKS AND HAZARDS FOR ALL SCENARIOS, ALL PATHWAYS

RME Receptor *	ILCR *	HI *
Current Land Use		
Groundskeeper	1.4×10^{-4}	1.1
Trespassing Child	1.1×10^{-5}	0.12
Off-Property Farm Residents		
Adult	1.2×10^{-4}	1.1
Child	9.0×10^{-6}	3.0
Future Land Use with Federal Ownership		
Expanded Trespasser	3.3×10^{-5}	0.24
Trespassing Child	1.1×10^{-5}	0.12
Off-Property Farm Residents		
Adult	2.0×10^{-4}	1.1
Child	1.3×10^{-5}	3.0
Future Land Use without Federal Ownership		
On-Property Farm Residents		
Adult (ingests perched ground water)	1.2×10^{-2}	22.0
Adult (ingests Great Miami Aquifer water)	5.0×10^{-3}	22.0
Child	8.2×10^{-4}	94.0
Off-Property Farm Residents		
Adult	2.0×10^{-4}	1.1
Child	1.3×10^{-5}	3.0

* ILCR = Incremental Lifetime Cancer Risk over a 70-year lifetime (NCP target range is 10^{-4} to 10^{-6})
* HI = Hazard Index not to exceed 1.0
* RME = Reasonable Maximum Exposure

ASSESS TOXICITY

- Carcinogenic
- Noncarcinogenic



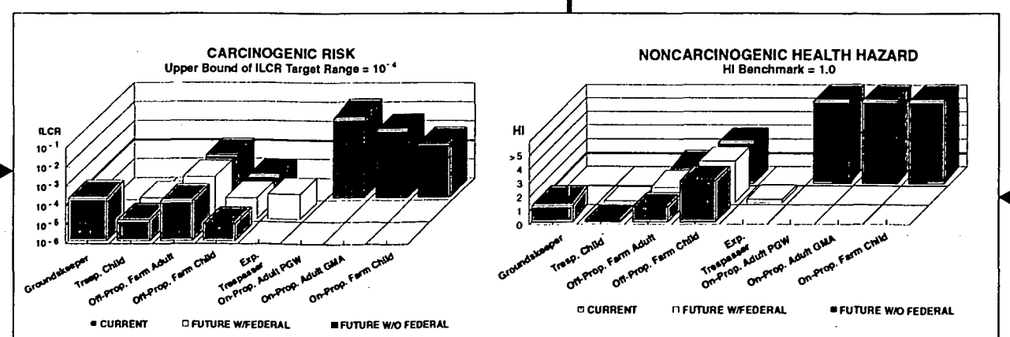
Radionuclide

Cs-137	Ru-106
Np-237	Sr-90
Pa-231	Tc-99
Pb-210	Th-228
Pu-238	Th-230
Pu-239	Th-232
Pu-240	U-234
Ra-226	U-235
Ra-228	U-236
Rn-222	U-238

Chemical

2-Methylnaphthalene	Cyanide
4,4-DDE	Endrin
Antimony	Lead
Aroclor-1221	Manganese
Aroclor-1248	Mercury
Aroclor-1254	Molybdenum
Aroclor-1260	Nickel
Arsenic	Selenium
Barium	Silver
Beryllium	TCDD
Boron	Thallium
Cadmium	Thorium
Carbazole	Uranium
Chromium	Vanadium
Cobalt	Zinc
Copper	

CHARACTERIZE RISK



The results of the human-health risk characterization were compiled and analyzed. Noncarcinogenic health hazards and carcinogenic health risks were summarized.

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I.1.0 INTRODUCTION

In accordance with the Amended Consent Agreement, a Comprehensive Response Action Risk Evaluation (CRARE) will be prepared for each operable unit at the Fernald Environmental Management Project (FEMP) site. The CRAREs estimate the cumulative human-health risks that will remain on-site following implementation of the remedial actions for the five operable units. Each operable unit feasibility study (FS) report will include a CRARE as an appendix. This is the second CRARE to be prepared and is submitted with the Operable Unit 2 FS report as the combined Operable Unit 1&2 CRARE.

The CRAREs use as a starting point the preferred remedial alternatives (PRAs) for Operable Units 1, 2, and 4 selected as a result of the comparative analysis of alternatives in the respective FS reports. Since the analyses for Operable Units 3 and 5 have not yet been completed, this CRARE uses the leading remedial alternatives (LRAs) from the Site-Wide Characterization Report (SWCR) for those operable units (DOE 1993e). When the Operable Unit 3 and 5 FSs are complete, the original LRAs will be updated with any changes necessary for consistency with the 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." Because the CRAREs are based in part on assumptions regarding site activities that are subject to change, all but the final CRARE (for Operable Unit 3) must be considered preliminary evaluations of final residual risk. One of the most important uses of the early CRAREs is to identify areas contributing the greatest risk and thus provide focus and direction to future data collection and analysis, as well as response action development.

The CRAREs for Operable Units 1, 2, and 4 address human health risk. A detailed, quantitative Ecological Risk Assessment (ERA) is included in the Operable Unit 5 Remedial Investigation (RI) report (site-wide baseline ecological risks can be found in the SWCR). Therefore, the Operable Unit 5 RI/FS and final CRARE will be used to evaluate the human and ecological residual risks of the remediated FEMP with respect to the National Contingency Plan (NCP) and U.S. Environmental Protection Agency (EPA) guidance.

I.1.1 CRARE OBJECTIVES

The objective of the CRARE is to estimate, from a site-wide perspective, the risk remaining after the FEMP has been remediated. This objective and other supporting objectives are depicted in Figure I.1-1. The figure also presents the iterative nature of the CRARE documents and demonstrates the scope of the CRARE analysis, according to the Risk Assessment Work Plan Addendum (RAWPA), dated June 1992 (DOE 1992i). The CRARE focuses on long-term residual risks after the remedial activities at the site have been completed. Short-term risks are addressed to a lesser extent and are presented quantitatively for each operable unit in its FS report. This information is integrated into a qualitative discussion addressing the remaining operable units. Eventually, after the FS and associated risk assessments are completed for each subsequent operable unit, the CRAREs may then include a more quantitative treatment of short-term transient risks and to some extent provide data to optimize the alternative remedial actions and their scheduled implementation.

This Operable Unit 1&2 CRARE:

- Quantifies operable-unit-specific contributions to site-wide potential human health risks, which include both potential carcinogenic (radiological and chemical) and noncarcinogenic effects.
- Provides information to address revisions of site-wide cleanup levels, based on associated carcinogenic and noncarcinogenic effects to human receptors.
- Incorporates operable-unit-specific information from the Operable Unit 1, 2, and 4 FS risk assessments (DOE 1993g, 1994b, and 1993h) and identifies areas of potential risk management per operable unit.

Human health-based cleanup levels are derived in each operable unit's RI as preliminary remedial goals (PRGs). During the FS process, the PRGs may be modified for various reasons, including administrative controls and considerations such as appropriate, relevant and applicable regulations (ARARs), and engineering controls and design constraints. Proposed remedial levels (PRLs) are approved by the EPA at the Record of Decision (ROD) stage after consideration of the modified PRGs (see Figure I.1-1).

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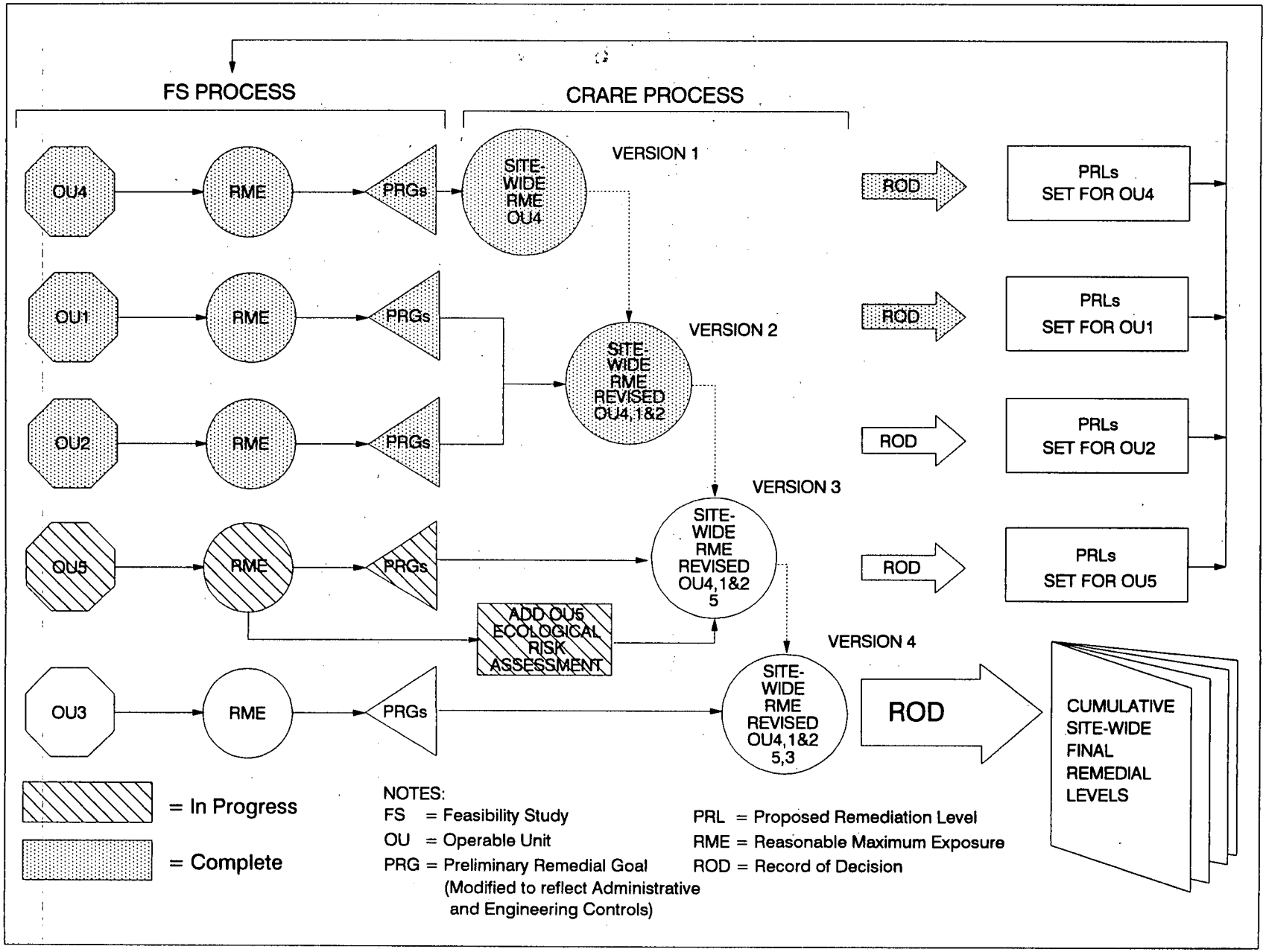

FIGURE I.1-1. ITERATIVE NATURE OF THE CRARE

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EPA's comments on previous versions of the CRARE have been addressed in this submission, with a few exceptions. The expanded trespasser, and possibly other receptors or more conservative exposure parameters, will be re-examined for the Operable Unit 5 CRARE. Central tendency analysis has been reviewed and is described in Section I.5.1.3 of this CRARE. Other specific information on Operable Unit 5, such as the PRA and the duration of groundwater and surface water treatment operations, will need to be examined.

I.1.2 FEMP SITE HISTORY

Formerly known as the Feed Materials Production Center, the FEMP (Figure I.1-2) is a contractor-operated federal facility where pure uranium metals were produced for the DOE from 1951 to 1989. No isotopic separation of uranium in the starting materials was performed. After production ceased, plant resources were focused on a cleanup program. In 1991, the FEMP was officially closed as a federal production facility, but the environmental studies and cleanup activities continued. The FEMP site is located on 425 hectares (1050 acres) in a rural area of Hamilton and Butler counties, approximately 29 kilometers (18 miles) northwest of Cincinnati, Ohio.

I.1.3 SITE DESCRIPTION

This section summarizes the regional and site-specific environment of the FEMP, focusing on the climate, geology, topography, surface water, hydrology, ecology, land use, and demographics. Additional information can be found in the Operable Unit 1, 2, and 4 FS reports and the SWCR.

I.1.3.1 Climate

Information on the local climate has been gathered from an on-property meteorological system installed in 1986, and the National Weather Service Office at the Greater Cincinnati Airport. The *Final Interim Report-Air, Soil, Water, and Health Risk Assessment in the Vicinity of FEMP* (IT 1986) indicated that data obtained from monitoring stations at the airport sufficiently represent local climate conditions.

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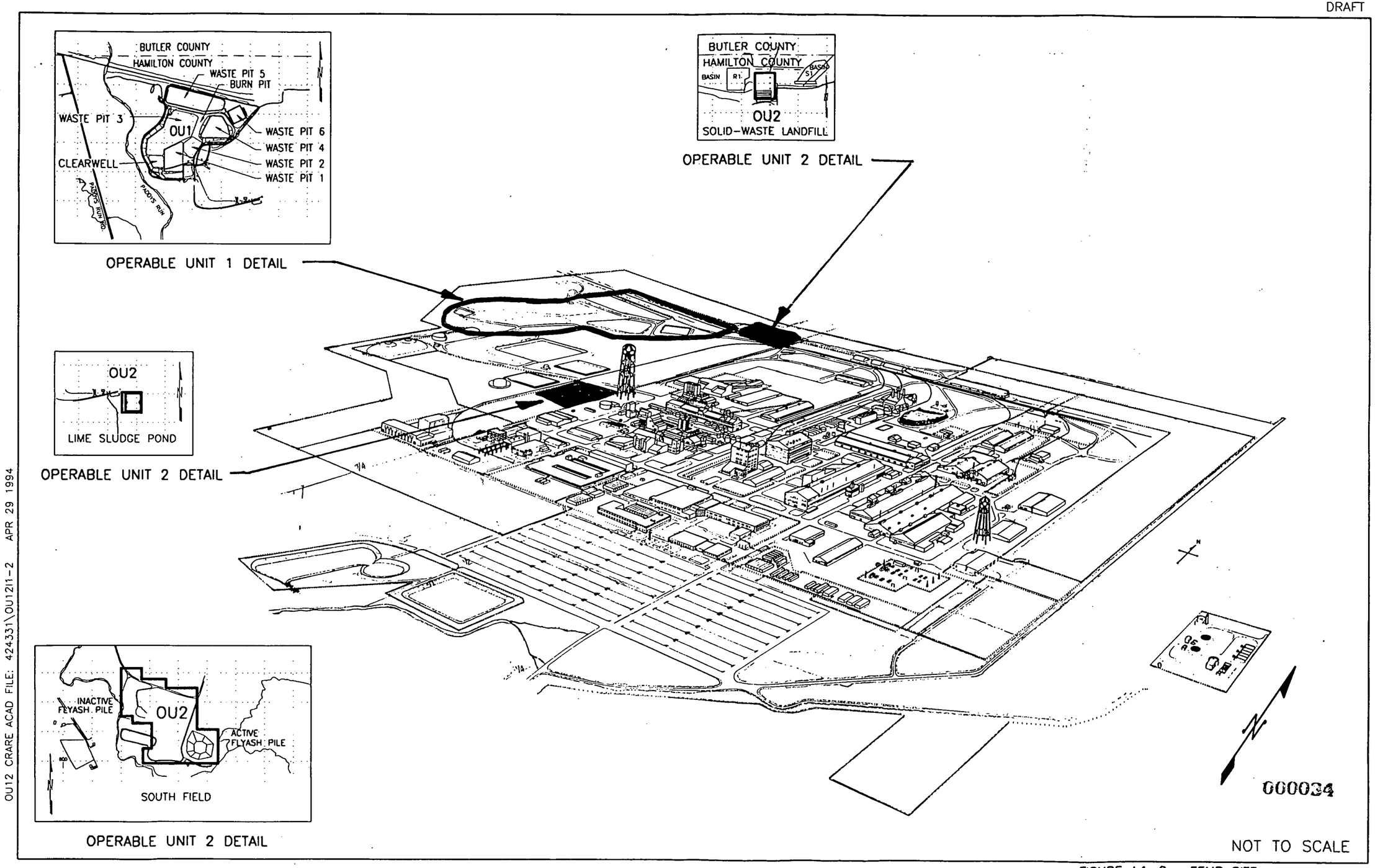

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FIGURE 1.1-2 FEMP SITE
OPERABLE UNIT 1&2 DETAIL

Winds

The prevailing winds are generally from the southwest and west-southwest. The average monthly wind speeds, based on National Weather Service meteorological data, range from 11 kilometers per hour (kph) or 7 miles per hour (mph) in August to 17.6 kph (11 mph) in March. For more information, refer to the SWCR or the Operable Unit 2 RI report.

Six years of meteorological data collected on-site indicate that the mean annual wind speed at the FEMP is approximately 7.3 kph (4.5 mph). The on-site data also indicate that the prevailing wind direction is from the southwest.

Precipitation

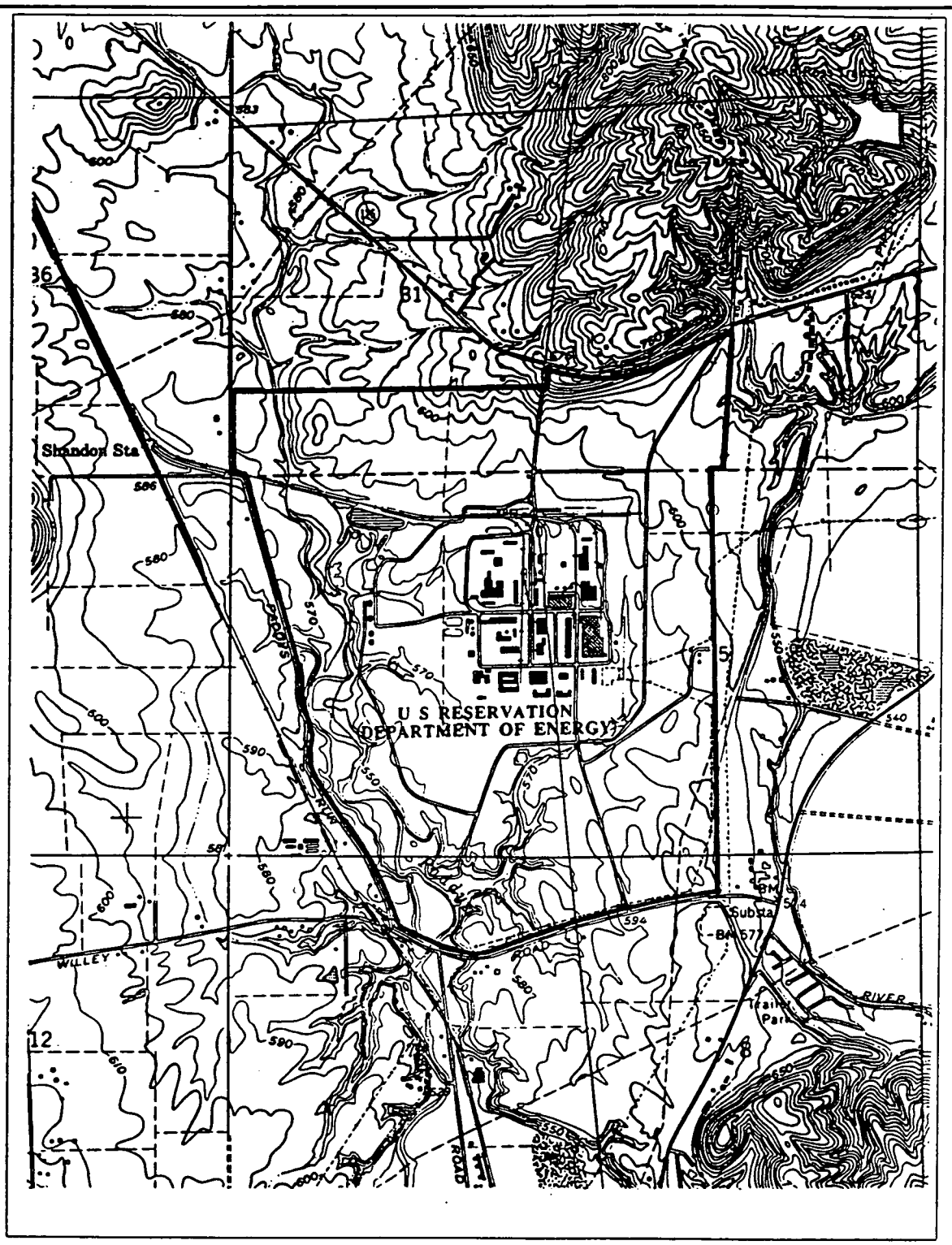
The average annual precipitation for the Cincinnati area from 1960 through 1989 was 103 centimeters (40.6 inches). The highest precipitation typically occurs during the spring and early summer, the lowest in the late summer and fall. The average annual snowfall for 1960 through 1989 was 59.7 centimeters (23.5 inches). The total rainfall for the area in 1991 was 102 centimeters (40.1 inches), and the total snowfall was 23.6 centimeters (9.3 inches). The wettest months in 1991 were August and December, with 12.8 and 12.9 centimeters (5.04 and 5.08 inches) of rainfall, respectively.

Temperature

The regional climate is defined as continental, with average monthly temperatures ranging from -1.55°C (29.2°F) in January to 24.3°C (75.7°F) in July. The highest temperature recorded from 1961 through 1989 was 39.4°C (103°F) in July 1988, and the lowest was -32°C (-25.6°F) in January 1977.

I.1.3.2 Topography and Surface Water Hydrology

The site topography and drainage channels are shown in Figure I.1-3. Maximum elevation along the northern boundary of the FEMP property is slightly more than 213.36 meters (700 feet) above mean sea level (MSL). The production and waste storage areas are on a relatively level plain at about 176.8 meters (580 feet) MSL. The plain slopes from 182.9 meters (600 feet) MSL along the eastern edge of the FEMP to 173.7 meters (570 feet) MSL at the K-65 silos, and then



SOURCE
USGS (1981)
SHANDON, OHIO
QUADRANGLE

SCALE
1:24,000

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FIGURE 1.1-3
TOPOGRAPHIC MAP OF THE FEMP

drops off towards Paddys Run stream at 167.64 meters (550 feet) MSL. All drainage on the property is generally from east to west into Paddys Run.

Paddys Run is a steep-sided stream that originates north of the FEMP and runs south along the western boundary of the facility. Paddys Run is approximately 14 kilometers (8.8 miles) long and drains an area of approximately 40.9 square kilometers (15.8 square miles). The stream is ungauged, but estimated flows for January through May range from 0.0057 to 0.113 cubic meters per second (cms) or 0.2 to 4.0 cubic feet per second (cfs). The stream is a tributary of the Great Miami River, which is three-quarters of a mile from the facility's eastern boundary at its closest point.

The FEMP lies within the Great Miami River drainage basin but is above the river's present-day floodplain. The Great Miami River is the main surface water feature in the vicinity and is the receiving water for National Pollutant Discharge Elimination System (NPDES) permitted discharge from the facility. The river flows generally to the southwest and drains an area of approximately 8702.4 square kilometers (3360 square miles).

The average discharge for the Great Miami River, based on 55 years of records, is 936 cms (3305 cfs). The maximum discharge ever recorded for the river occurred on March 26, 1913 and was estimated to be 9968.6 cms (352,000 cfs). The 10-year flood discharge has been calculated to be 2306.8 cms (81,455 cfs). The minimum daily discharge of 4.4 cms (155 cfs) was recorded on September 27, 1941.

I.1.3.3 Geology and Hydrology

At the FEMP, groundwater occurs in the glacial overburden as perched water, in a sand and gravel aquifer (the Great Miami Aquifer), and to a lesser extent in the underlying bedrock. Perched water occurs when water sinking through the earth from the surface is retarded above a very dense stratum, in this case clay. This perched water either seeps slowly downward through the clay or flows horizontally to discharge sites in Paddys Run. At the FEMP, perched water is generally found between 0.3 and 3 meters (1 and 10 feet) below the surface (SWCR).

The glacial overburden, which occurs under most of the FEMP property, is composed of the following: loess, fine-grained silt with small amounts of clay; lacustrine deposits, silt and clay with interbedded sand; till, heterogeneous mixture of silt, clay, sand, gravel, and boulder-sized materials; and glaciofluvial deposits, well-sorted sand and gravel. The thickness of the glacial overburden ranges from 1.5 to 15 meters (5 to 50 feet) within the FEMP study area, but most often averages between 6.1 and 9.1 meters (20 and 30 feet). With the exception of some scattered deposits, this material does not exist along the floodplain of the Great Miami River to the east and south of the FEMP. The only on-property areas that lack overburden are certain reaches of Paddys Run and the storm sewer outfall ditch, where the material has eroded away.

The presence of till and deposits of silt and clay classifies the overburden as an aquitard in most locations. However, perched water zones are formed from the lenses, beds, and irregularly shaped deposits of sand and gravel interbedded within the till. A series of slug tests performed in the on-property wells screened in the perched-water zones found hydraulic conductivities ranging from 0.002 to 4.5 meters per day (0.0065 to 14.7 feet per day). Porosities range from 22.1 to 36.7 percent with a mean of 31 percent (Morris and Johnson 1967). Based on hydrography analyses, the interconnection between perched-water zones is limited, indicating that the movement of water and contaminants within and among these units is limited. The till is considered to be saturated from the perched water zones down to the top of the glaciofluvial deposits.

Water seeping through the clay layer passes through the glacial overburden and collects in the underlying aquifer. The Great Miami Aquifer, is about 24.4 meters (80 feet) beneath the FEMP and ranges between 38.1 and 53.3 meters (125 and 175 feet) in thickness. Flow in the aquifer is to the southeast and south, toward the Great Miami River.

I.1.3.4 Ecology

Plant and wildlife communities within FEMP boundaries have been extensively characterized by Facemire et al. (1990), who provide detailed data on species abundances. Habitats include grazed and ungrazed pastures, pine plantations, deciduous woodlands, riparian woodlands, and a "reclaimed" flyash pile, which overlaps the inactive flyash pile and South Field. The inactive flyash pile and South Field have been colonized by American elm, eastern cottonwood, black locust, redbud, and box elder. Herbaceous species are also present. Common mammals include the

white-tailed deer, eastern cottontail rabbit, coyote, red fox, and several smaller animals such as the white-footed mouse, short-tailed shrew, and eastern chipmunk.

I.1.3.5 Land Use

Most of the land surrounding the FEMP is devoted to farming and to raising dairy and beef cattle. Major crops include field corn, sweet corn, soybeans, and winter wheat. Other important commercial activities include sand and gravel mining and potable water extraction from the adjacent Great Miami Aquifer. Many sand and gravel operations exist along the river, and the Southwest Ohio Water Company Southwest Ohio Water Company is 2 kilometers (1.25 miles) upstream of the FEMP discharge line to the river.

I.1.3.6 Demographics

Scattered residences and several villages, including Fernald, New Baltimore, Ross, New Haven, and Shandon, are near the FEMP. Downtown Cincinnati is approximately 29 kilometers (18 miles) southeast, and the cities of Hamilton and Fairfield are approximately 9.7 to 13 kilometers (6 to 8 miles) to the northeast. More than 24,000 people live within 8 kilometers (5 miles) of the facility center, the nearest resident within 1.2 kilometers (0.75 miles). The Knollman Dairy Farm is on Willey Road, just outside the southeast corner of the FEMP property boundary. Several residences are located off Paddys Run Road, approximately 1.6 kilometers (1 mile) south of property boundaries.

I.1.4 OPERABLE UNITS

The FEMP was divided into five operable units under the original 1990 Consent Agreement, and the units were redefined under the Amended Consent Agreement. Figure I.1-4 shows the existing FEMP site. The five operable units are detailed in Figures I.1-5 through I.1-9; their revised definitions are presented below:

- Operable Unit 1:

  Waste Pits 1 through 6, the Clearwell, burn pit, berms, liners, and associated contaminated soil within the operable unit boundary. Waste Pits 3 and 5 and the Clearwell also contain water, including perched water (Figure I.1-5).

- Operable Unit 2:

  The active and inactive flyash piles, South Field, lime sludge ponds, solid-waste landfill, berms, liners, and associated contaminated soil and perched water within the operable unit boundary (Figure I.1-6).

- Operable Unit 3:

  The production area and associated facilities and equipment including all structures, equipment, utilities, drums, tanks, solid waste, waste product, effluent lines, K-65 transfer line, wastewater treatment facilities, fire training facilities, scrap metal piles, feed stocks, and the coal pile (Figure I.1-7).

- Operable Unit 4:

  Silos 1, 2, 3, and 4, berms, decant tank system, radon treatment system, and associated contaminated soil and perched water within the operable unit boundary (Figure I.1-8).

- Operable Unit 5:

  Perched and regional groundwater, surface water, soil not associated with other operable units (e.g., hot spots not previously identified). Also, soil and perched water beneath the Operable Unit 3 (Figure I.1-9).

I.1.5 FEMP REMEDIATION

The RI/FS activities at the FEMP have led to the development and implementation of removal actions. As defined in the Amended Consent Agreement, removal actions abate, minimize, stabilize, mitigate, or eliminate the release or threatened release of hazardous substances, pollutants, contaminants, or hazardous constituents at the FEMP. A significant purpose of the SWCR and its associated baseline risk assessment has been to provide data and risk analyses of the effects of any removal actions completed as of March 1993, the publishing date for SWCR data. Because the CRARE is a postremediation document, by definition all removal actions will have been completed well before the time periods examined in the CRARE.

The remedial action time frame is currently assumed to last from 30 to 70 years (for more information see Section I.2.1.

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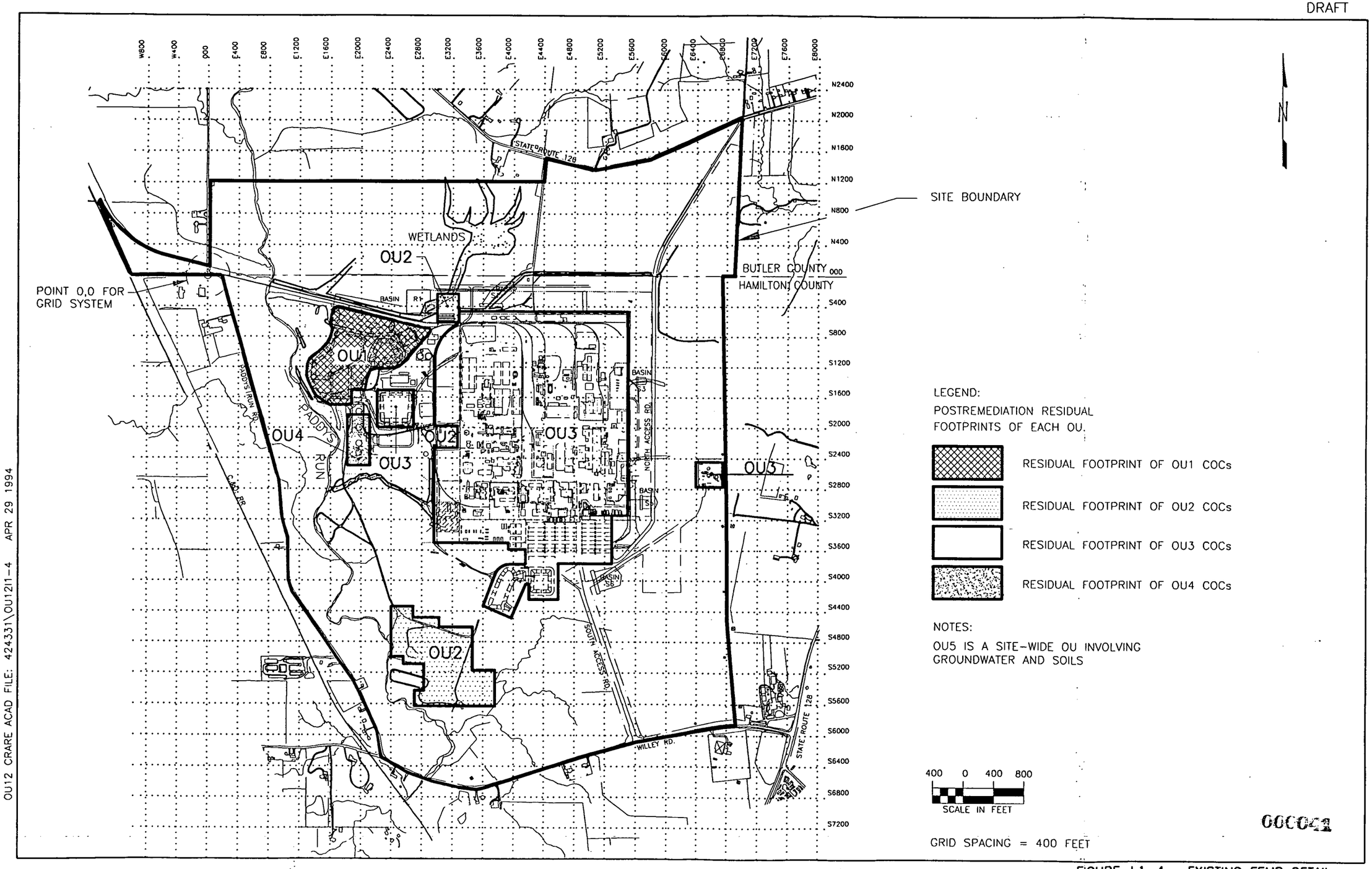

FIGURE 1.1-4 EXISTING FEMP DETAIL

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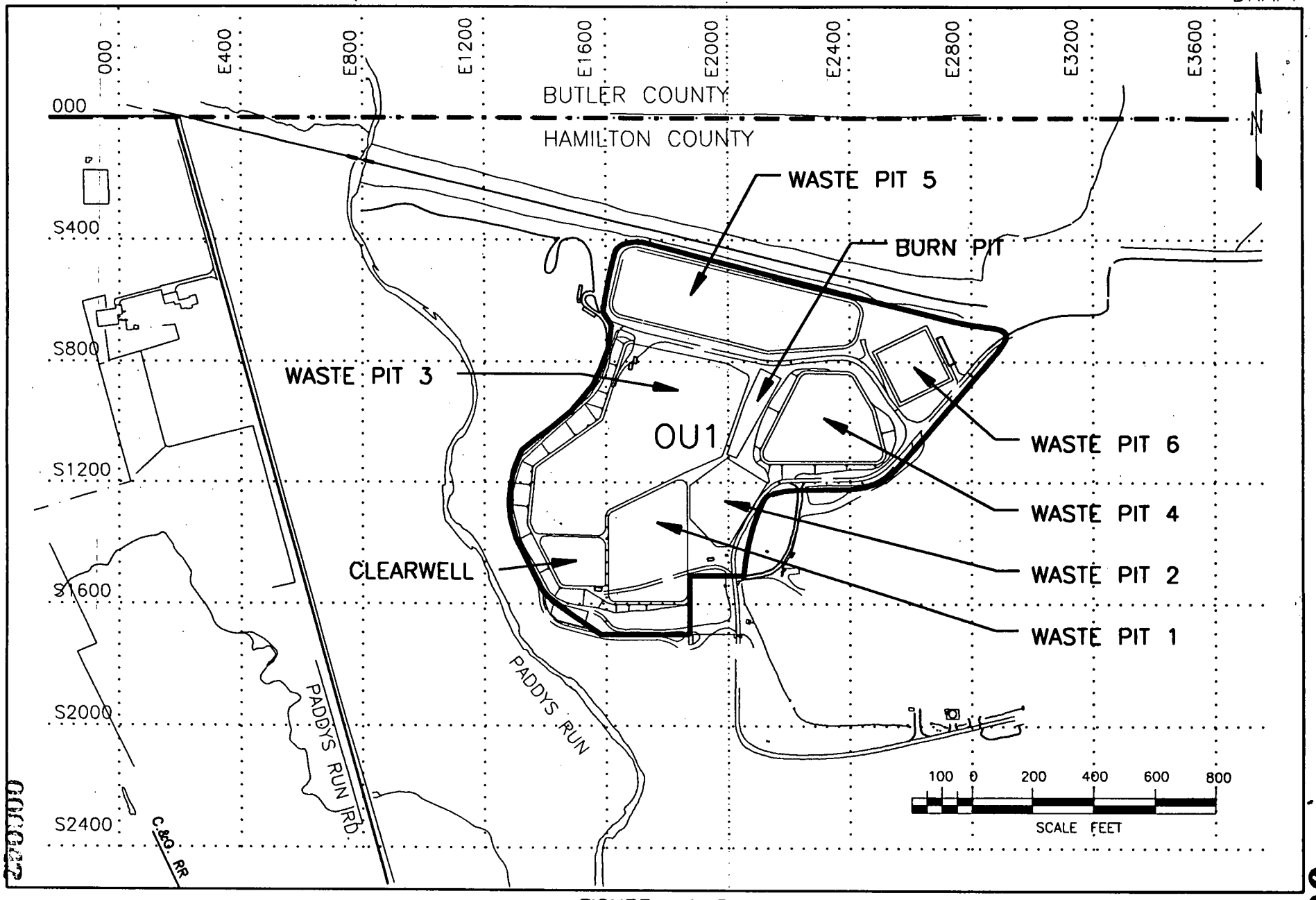

FIGURE 1.1-5
EXISTING DETAIL, OPERABLE UNIT 1

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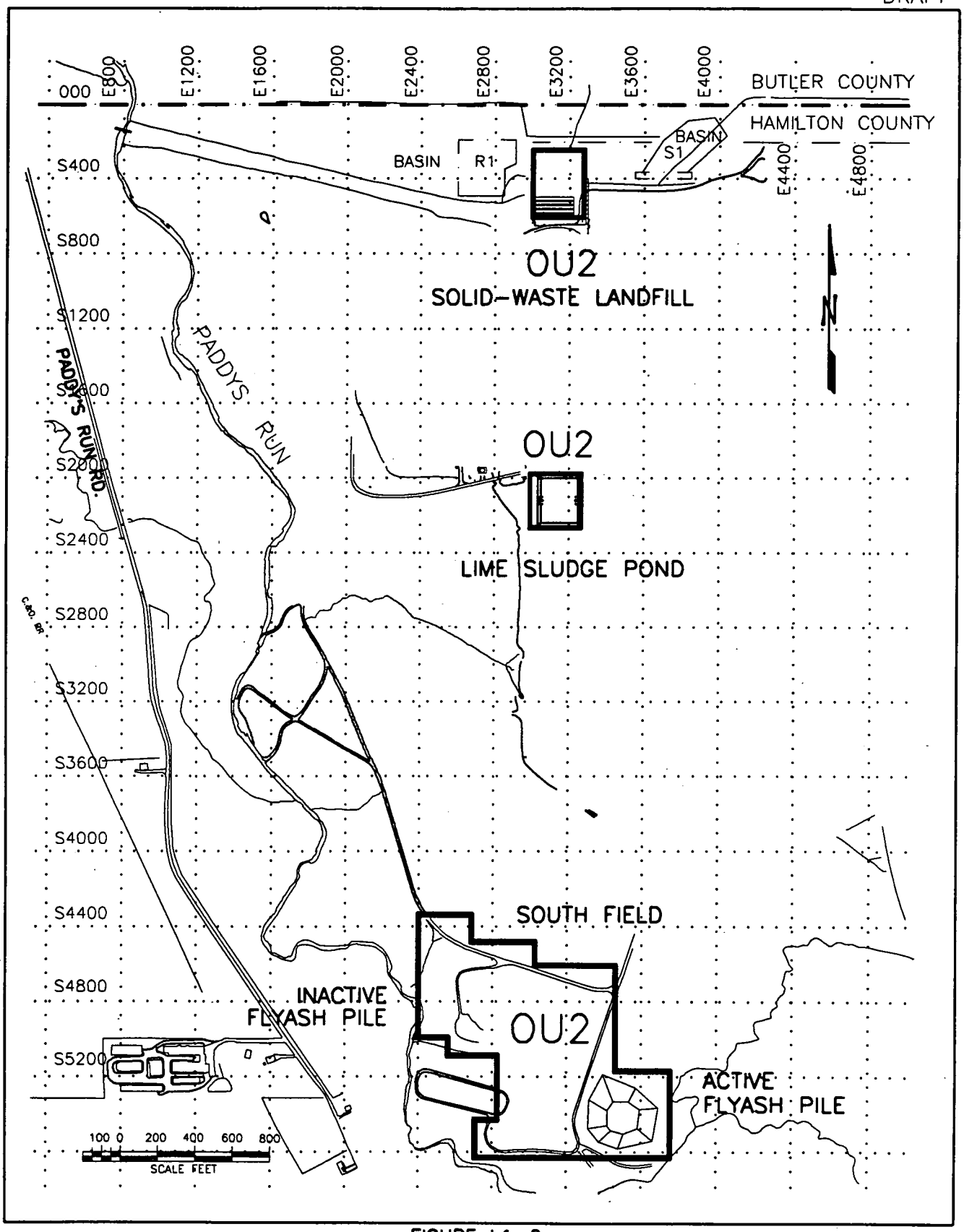

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FIGURE 1.1-6
EXISTING DETAIL, OPERABLE UNIT 2

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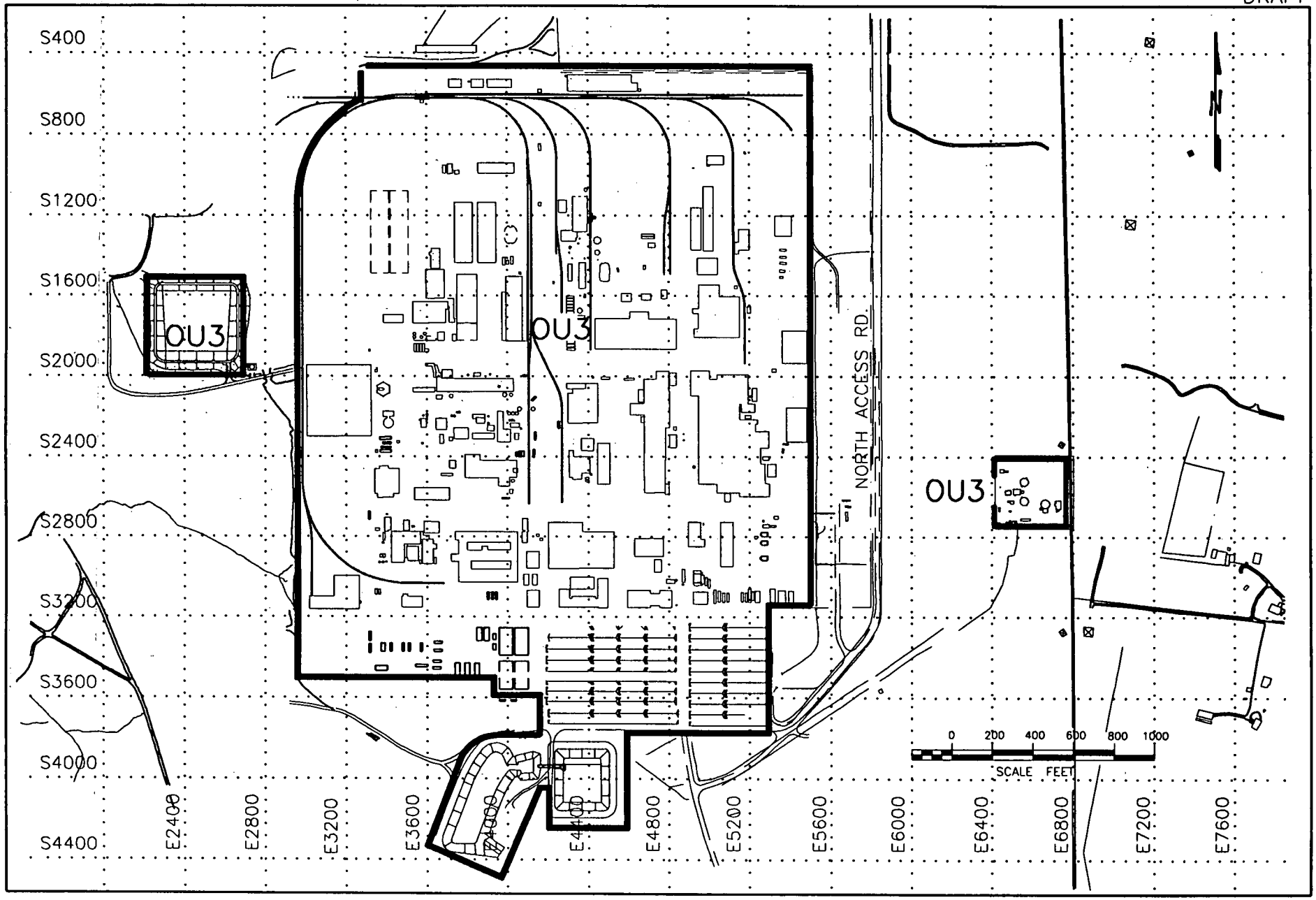

FIGURE 1.1-7
EXISTING DETAIL, OPERABLE UNIT 3

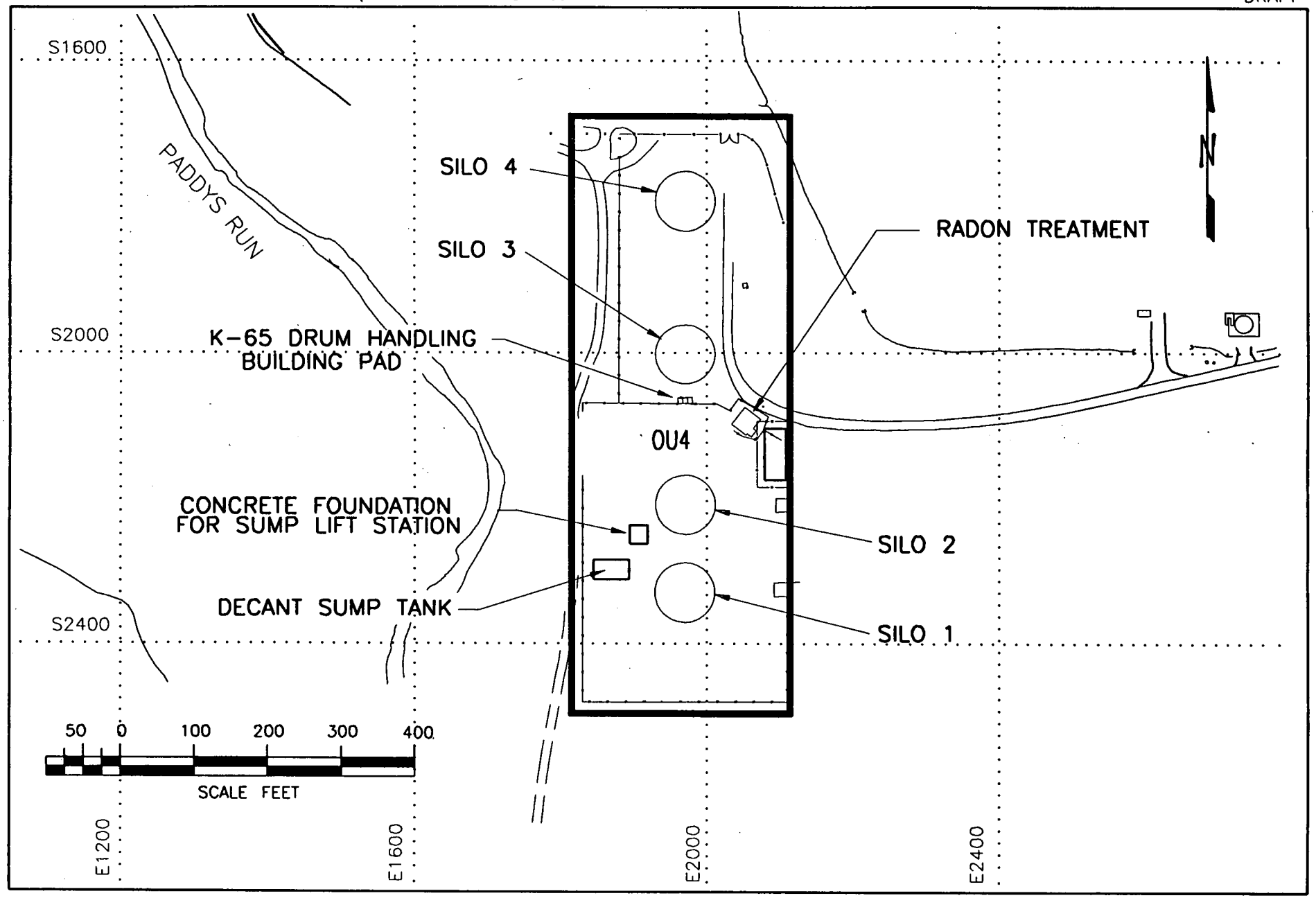

FIGURE 1.1-8
EXISTING DETAIL, OPERABLE UNIT 4

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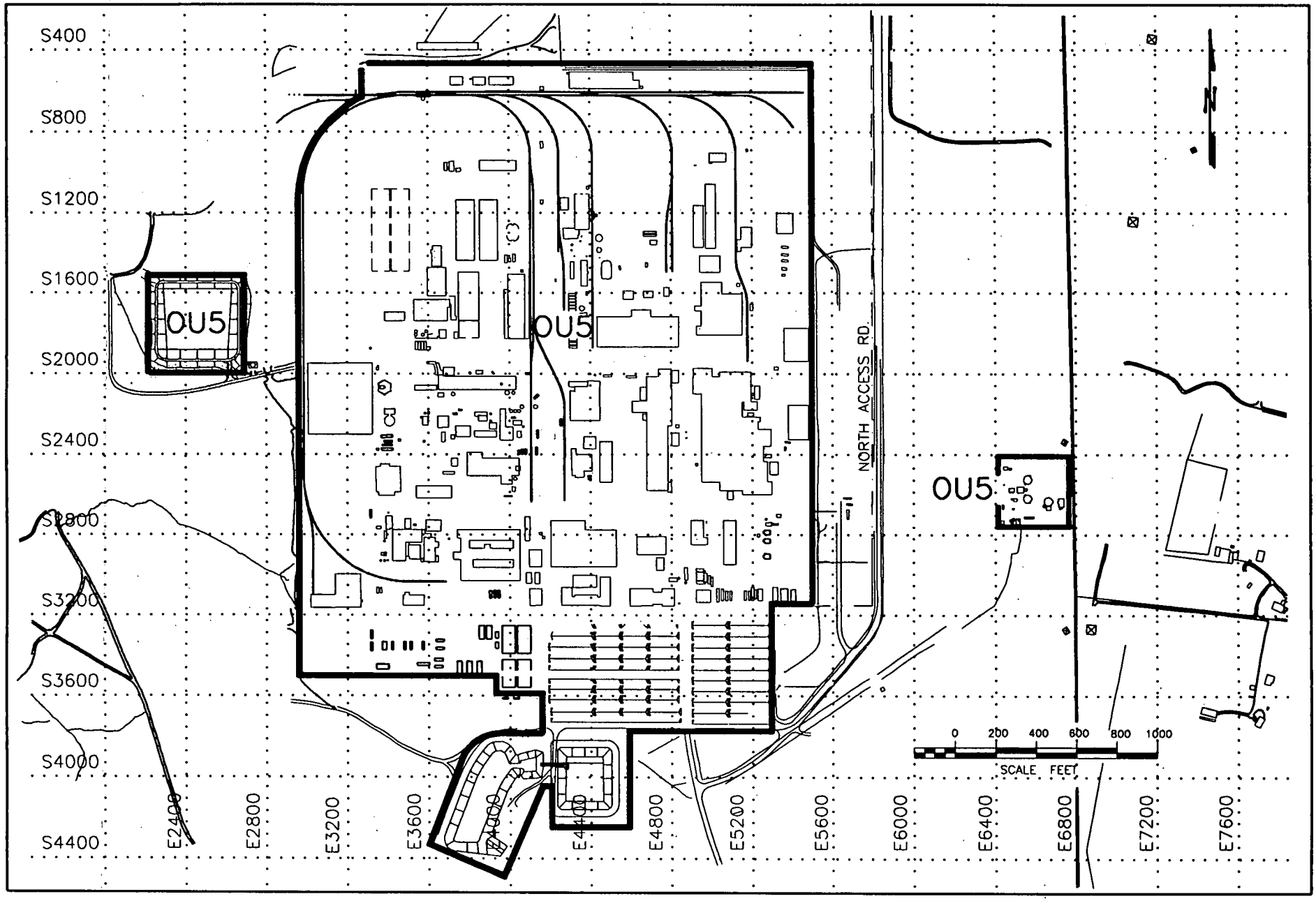

FIGURE 1.1-9
EXISTING DETAIL, OPERABLE UNIT 5 (SOILS)

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I.1.6 CRARE SITE-WIDE CONCEPTUAL MODEL

The CRAREs examine specific time periods after the remediation of all operable units is complete. They are not intended to provide information on current risks or risks during remediation. A key component of the CRAREs is the CRARE Site-Wide Conceptual Model, which examines current and future land uses for the periods immediately after and for up to 1000 years after all remedial actions are complete. The model depicts the final combination of FS remedial alternatives to ensure the FEMP achieves a residual risk that protects human health and the environment on a site-wide basis.

The health effects quantified in the CRAREs include: 1) the excess incremental lifetime cancer risk (ILCR) for exposure to chemical carcinogens, 2) the hazard quotient (HQ) for exposure to noncarcinogens, and 3) the carcinogenic effects to human receptors caused by exposure to radionuclides.

Figure I.1-10 provides an overview of the contaminated sources for the five operable units from remedial action to remediated site conditions. For each operable unit, the conceptual model depicts the remedial alternatives anticipated for implementation. Potential releases from the source areas form the basis for pathway evaluation. After site-wide remediation is complete, it is assumed that all existing structures would be removed. As shown in the figure, the remaining features and contaminant sources at the FEMP would be:

- Permanent disposal facilities known as vaults
- Capped or covered areas
- Areas where treated soil has been placed
- Residual contamination (surface soils)

The CRARE Site-Wide Conceptual Model graphically represents the sources, release mechanisms, transport-media and risk pathways for various human receptors under the Current and two Future Land Use scenarios of the five operable units. The Current Land Use scenario describes the FEMP for 70 years starting immediately after all remedial actions are complete. The 70-year period is based on the RAWPA, and is the life span of an individual. The scenario assumes DOE ownership, site access control, and maintenance of the FEMP and associated remedial structures for 70 years. The only remaining treatment facility active on the site at the

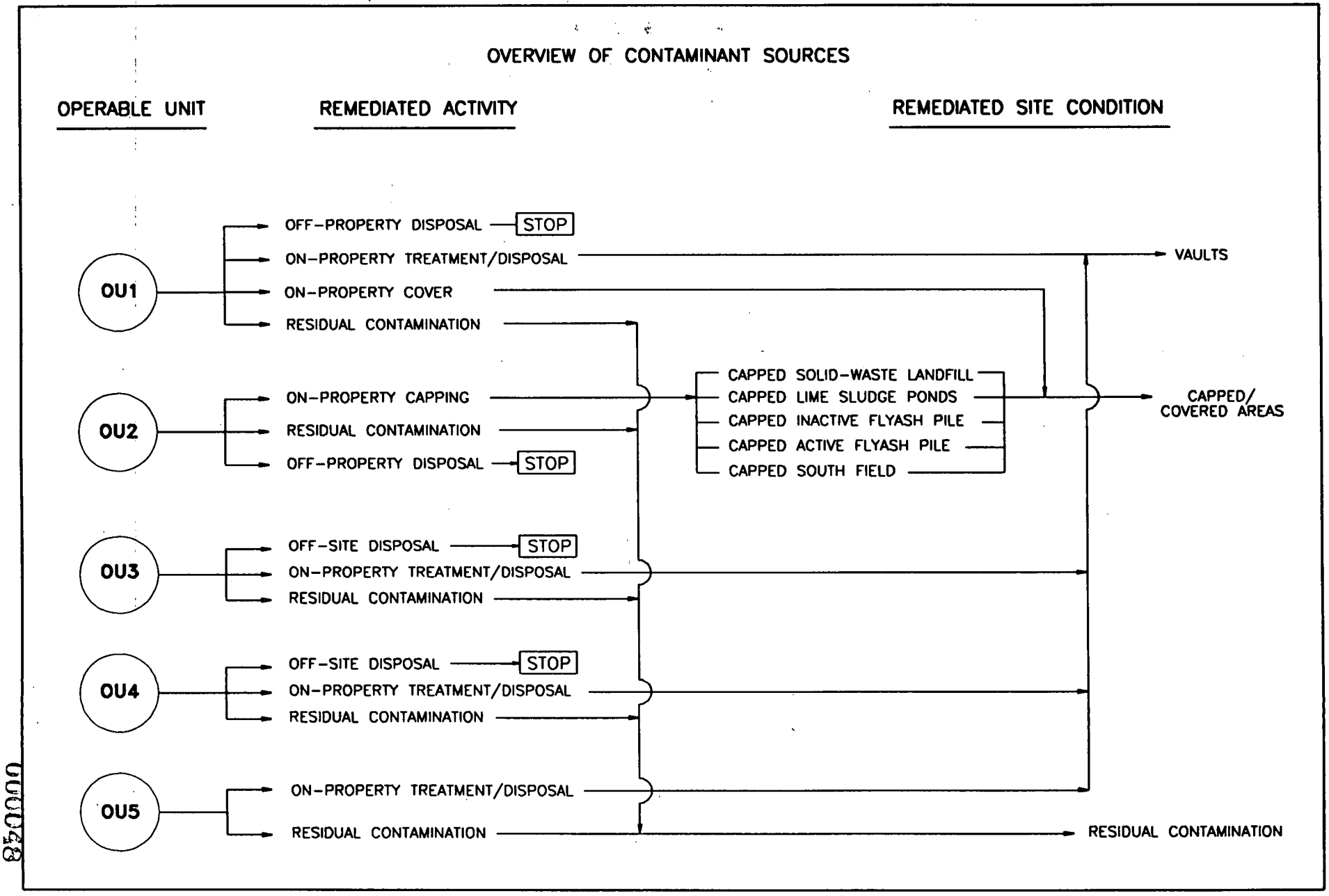

FIGURE I.1-10

OVERVIEW OF CONTAMINANT SOURCES, OPERABLE UNITS 1 THROUGH 5

start of the 70 years should be the wastewater treatment plant in Operable Unit 5, which itself may operate for 70 years.

The two Future Land Use scenarios describe the FEMP for up to 1000 years after all remedial actions are complete: Future Land Use With Federal Ownership assumes continued government ownership and land use restrictions, while Future Land Use Without Federal Ownership assumes occupation by a resident farm. Both future scenarios assume no access control, maintenance, or treatment operations. Contaminant fate and transport have been modeled for 1000 years.

Figure I.1-11 presents the Current Land Use scenario and displays the risks and exposure pathways for seven human receptors. The center portions of the figure represent each exposure pathway by which radioactive or chemical contaminants of concern (COCs) migrate from their sources to human receptors on and off the FEMP. For each exposure pathway, the following elements are addressed:

- Contaminant sources
- Secondary sources
- Release mechanisms
- Transport media
- Exposure points
- Exposure routes
- Primary exposed populations (receptors)

Figures I.1-12 and 13 present the scenarios covering the 1000-year postremediation period. Both of these Future Land Use scenarios assume no ongoing treatment activities. The scenario without federal ownership assumes a total loss of institutional controls.

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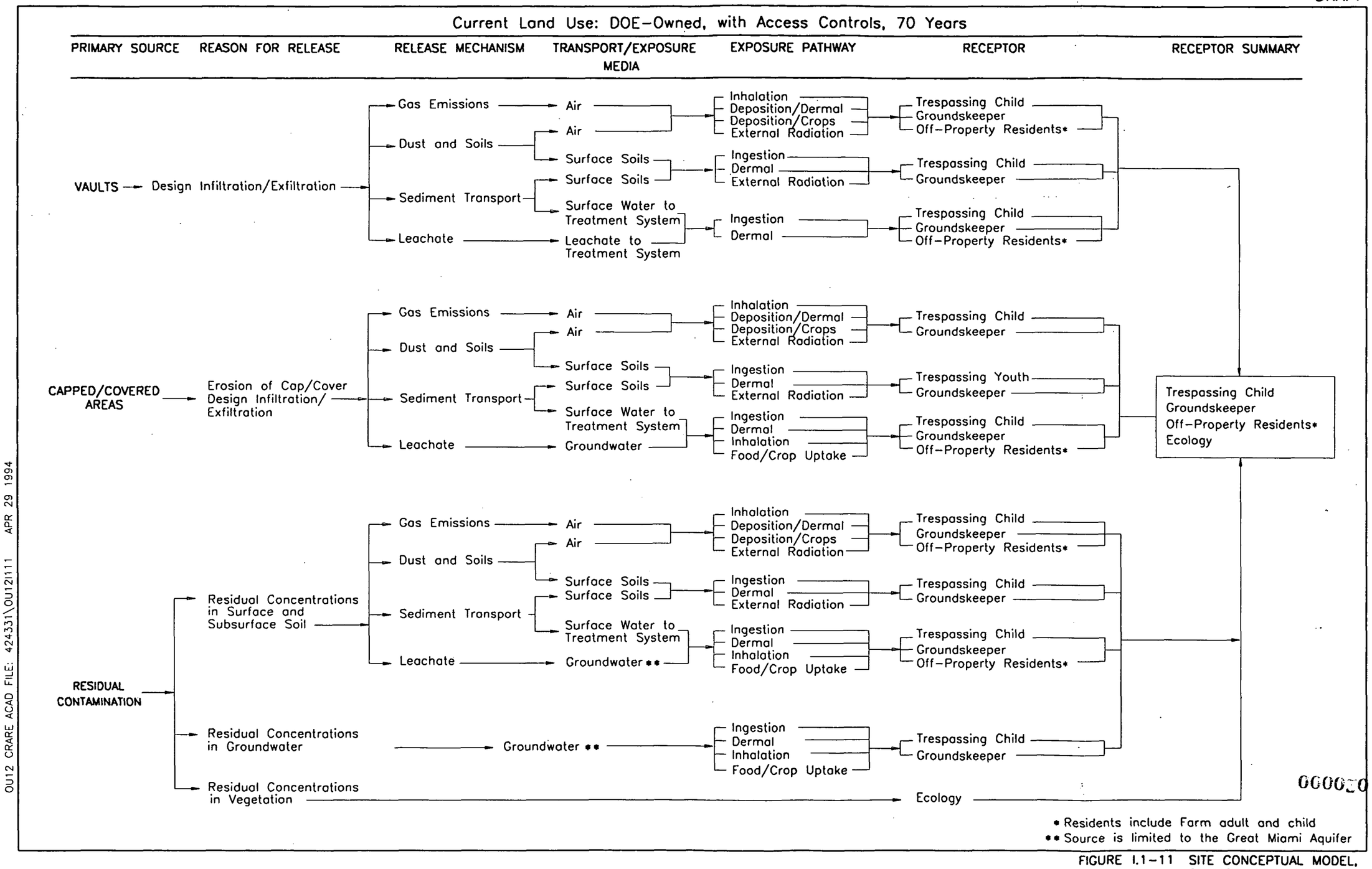

FIGURE 1.1-11 SITE CONCEPTUAL MODEL, CURRENT LAND USE

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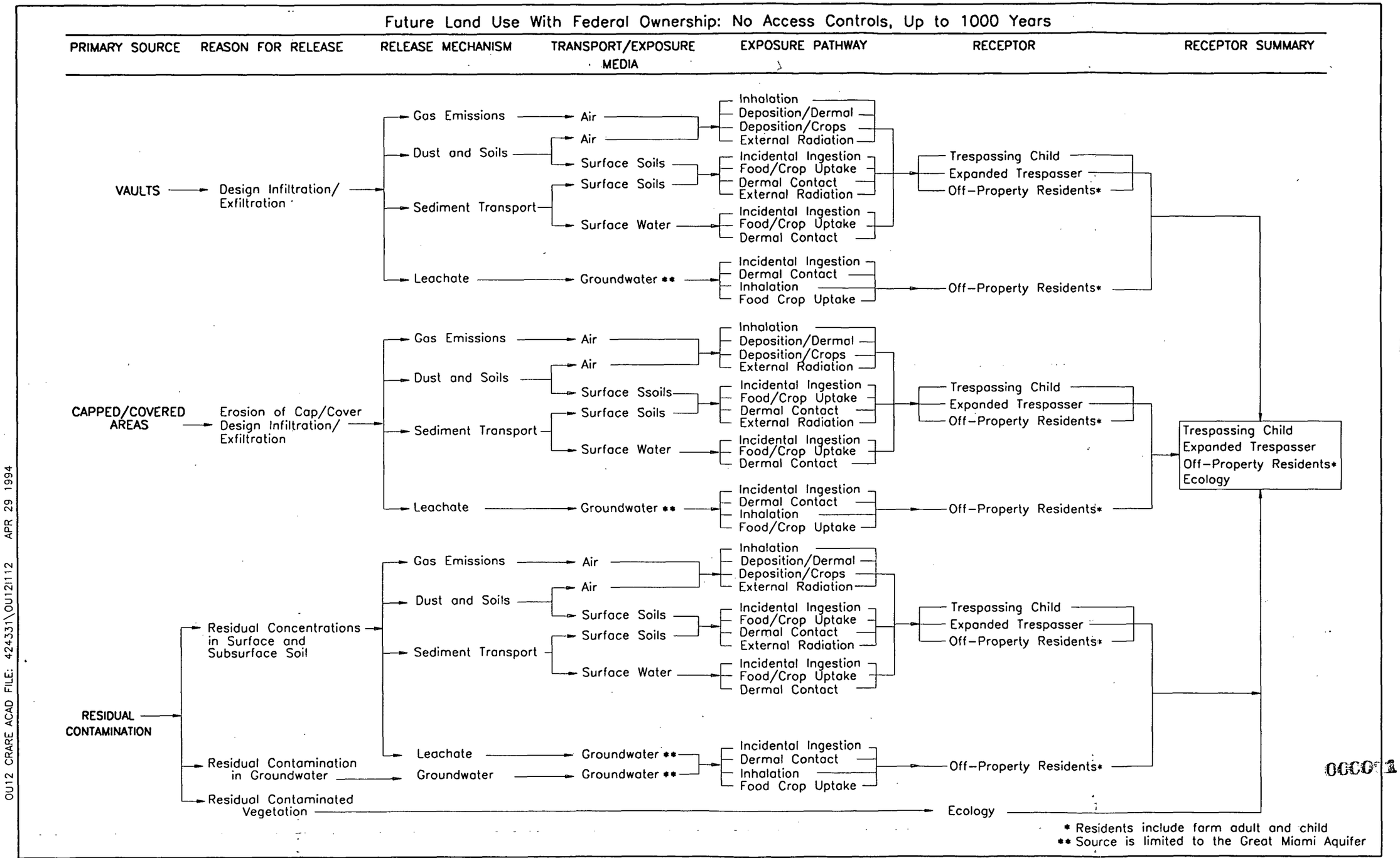

OU12 CRARE ACAD FILE: 424331\OU12I112 APR 29 1994

FIGURE 1.1-12 SITE CONCEPTUAL MODEL, FUTURE LAND USE WITH FEDERAL OWNERSHIP

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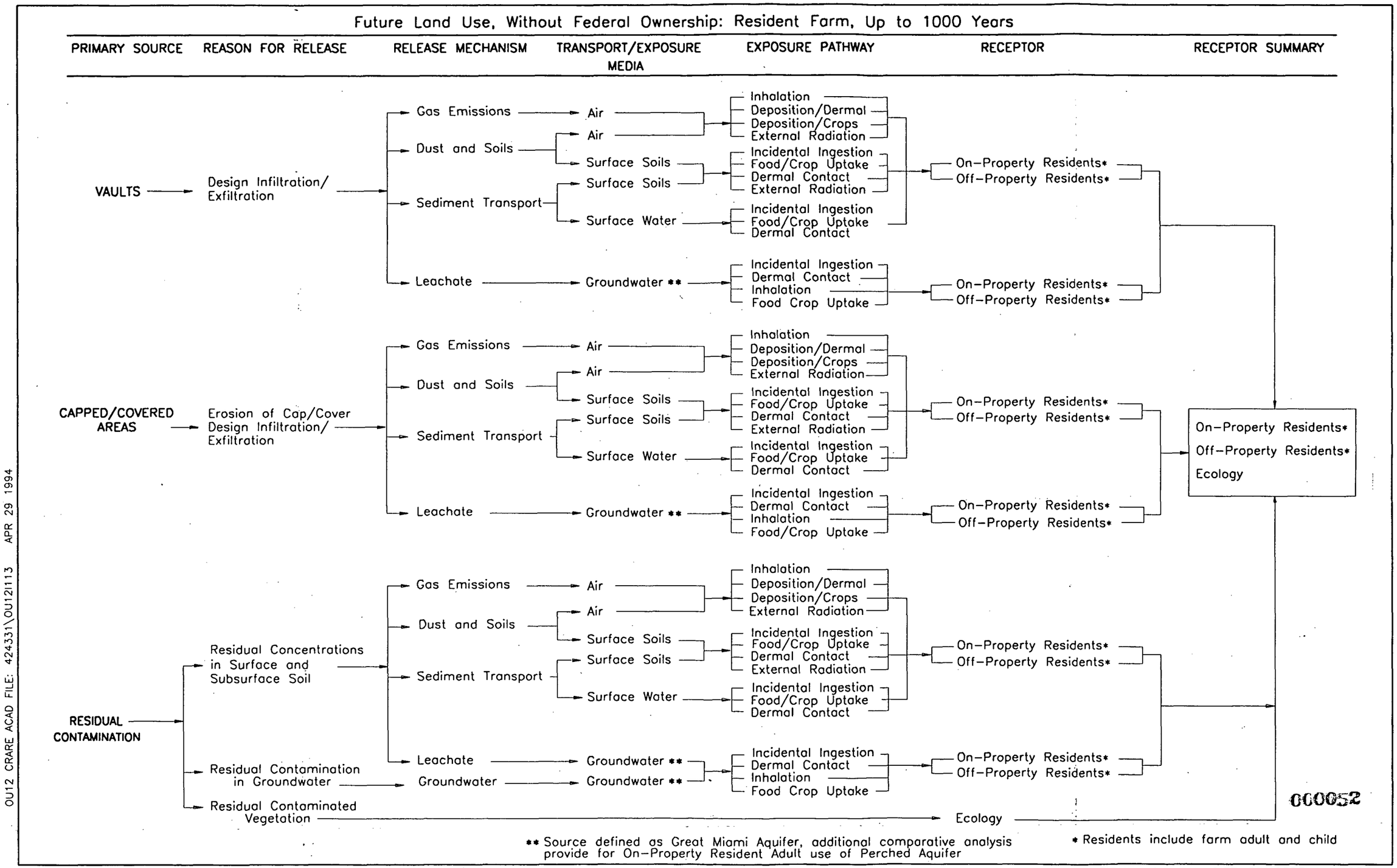

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FIGURE 1.1-13 SITE CONCEPTUAL MODEL, FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

Throughout the conceptual model, terminology for release mechanisms, transport media, exposure routes, etc. have used a limited set of technical terms for ease of use and understanding. As each subsequent operable unit is examined individually, the pathway model will become more complex, improving its ability to predict future situations. Receptors have been standardized in the model to reflect the three CRARE scenarios (Table I.1-1).

TABLE I.1-1

CRARE SCENARIOS AND RECEPTORS

Scenario	Time Frame	RME Receptor
Current Land Use	70 years after remedial actions are complete	Groundskeeper Trespassing Child Off-Property Farm Residents: Adult Child
Future Land Use With Federal Ownership	1000 years after remedial actions are complete	Expanded Trespasser Trespassing Child Off-Property Farm Residents: Adult Child
Future Land Use Without Federal Ownership	1000 years after remedial actions are complete	On-Property Farm Residents: Adult (ingests Great Miami Aquifer water) Adult (ingests perched groundwater) Child Off-Property Farm Residents: Adult Child

See Section I.5.0 for a discussion of all receptors initially evaluated.

These same receptors are used as the primary exposed population in the risk assessments for each of the five operable units. It is anticipated that by using standard receptors, the cumulative risks for all operable unit CRAREs can be readily added and compared. A more detailed discussion of this concept, as well as a description of the receptors, is presented in Section I.5.

The pathways considered include soil ingestion, external radiation, inhalation, exposure to native vegetation, farm crops, invertebrate fish and wildlife, farm animals, milk, and subsequent human uptake. The conceptual model is presented as a basis to develop risk pathways for each CRARE. As the RI/FS process proceeds, the model evolves to reflect the actual remedial action for each operable unit. This is a dynamic process, subject to input from many parties at the FEMP.

Table I.1-2 compares the land uses and receptors for the RI, FS, and CRARE reports. Because the CRAREs encompass a site-wide evaluation, they differ slightly from the RI and FS reports, which are prepared for single operable units.

I.1.7 ORGANIZATION OF THE CRARE

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

- I.1.0 Introduction:

  This section outlines the methodology to be used in preparing the FEMP CRAREs. It serves as a protocol with an emphasis on the procedures and techniques for characterizing the possible risks related to the remediated FEMP site.

- I.2.0 Overview of Information Base and Assumptions:

  This section describes the development of several factors and assumptions that have been employed for the CRARE. Some assumptions have significant bearing on the interpretation of the proposed approach. Generic site conditions, as well as data completeness, future facility management, demographics, and material containment assumptions, have been addressed. Additionally, the remedial alternatives for the other operable units are presented.

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TABLE I.1-2
CONSISTENCY OF LAND USE AND RECEPTOR SCENARIOS: OPERABLE UNIT 1, 2, AND 4 REPORTS

Report	Land Use	Ownership	Access	Use	RECEPTORS										
					Grounds-keeper	Trespassing Child	Expanded Trespasser	Off-Property Farm	Consumer of Animal Products[d]	On-Property Farm	River User	Visitor	On-Property CT Resident	Home Builder	Perched GW User
OU1 RI[a]	Current Land Use With Access Controls	Federal	Limited	Industrial				•				•			
	Current Land Use Without Access Controls	Federal	Unlimited	Farm		•		•	•						
	Current Land Use Without Access Controls	Private	Unlimited	Gov't Reserve		•		•	•		•				
	Future Land Use	Private	Unlimited	Farm						•			•	•	
OU2 RI[b]	Current Land Use DOE Ownership	Federal	Limited	Gov't Reserve		•		•							
	Future Land Use With Federal Ownership	Federal	Unlimited	Gov't Reserve			•	•							
	Future Land Use Without Federal Ownership	Private	Unlimited	Farm						•			•	•	•
OU4 RI[c]	Current Land Use With Access Controls	Federal	Limited	Gov't Reserve		•		•			•				
	Current Land Use Without Federal Ownership	Federal	Limited	Gov't Reserve	•	•		•			•				
	Future Land Use Without Federal Ownership	Private	Unlimited	Farm				•		•	•		•		

[a] Operable Unit 1 Remedial Investigation Report, October 1993
[b] Operable Unit 2 Remedial Investigation Report, January 1994
[c] Operable Unit 4 Remedial Investigation Report, November 1993
[d] The consumer of animal products receptor was included as a portion of the on/off-property farm scenario in OU1 and OU4 risk evaluations.

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TABLE I.1-2
(Continued)

Report	Land Use	Ownership	Access	Use	RECEPTORS										
					Grounds-keeper	Trespassing Child	Expanded Trespasser	Off-Property Farm	Consumer of Animal Products[d]	On-Property Farm	River User	Visitor	On-Property CT Resident	Home Builder	Perched GW User
OU1 FS[a]	Future Land Use With Access Controls	Federal	Limited	Gov't Reserve			•	•							
	Future Land Use Without Access Controls	Private	Unlimited	Farm			•	•		•					
OU2 FS[b]	Current Land Use DOE Ownership	Federal	Limited	Gov't Reserve		•		•							
	Future Land Use With Federal Ownership	Federal	Unlimited	Gov't Reserve			•	•							
	Future Land Use Without Federal Ownership	Private	Unlimited	Farm						•			•	•	•
OU4 FS[c]	Current Land Use With Access Controls	Federal	Limited	Gov't Reserve		•		•			•				
	Current Land Use Without Access Controls	Private	Limited	Industrial		•		•			•				
	Future Land Use Without Access Controls	Private	Unlimited	Farm				•		•	•		•		

[a] Operable Unit 1 Feasibility Study Report, March 1994
[b] Operable Unit 2 Feasibility Study Report, January 1994
[c] Operable Unit 4 Feasibility Study Report, December 1993
[d] The consumer of animal products receptor was included as a portion of the on/off-property farm scenario in OU1 and OU4 risk evaluations.

TABLE I.1-2
(Continued)

Report	Land Use	Ownership	Access	Use	RECEPTORS										
					Grounds-keeper	Trespassing Child	Expanded Trespasser	Off-Property Farm	Consumer of Animal Products[c]	On-Property Farm	River User	Visitor	On-Property CT Resident	Home Builder	Perched GW User
OU1&2 CRARE[a]	Current Land Use With Access Controls	Federal	Limited	Gov't Reserve	•	•		•							
	Future Land Use With Access Controls	Federal	Limited	Gov't Reserve		•	•	•							
	Future Land Use Without Access Controls	Private	Unlimited	Farm				•		•					•
OU4 CRARE[b]	Current Land Use DOE Ownership	Federal	Limited	Gov't Reserve	•	•		•							
	Future Land Use With Federal Ownership	Federal	Limited	Gov't Reserve			•	•							
	Future Land Use Without Federal Ownership	Private	Unlimited	Farm				•		•					

[a] Operable Unit 1&2 CRARE Report, April 29, 1994
[b] Operable Unit 4 CRARE Report, February 1994
[c] The consumer of animal products receptor was included as a portion of the on/off-property farm scenario in OU1 and OU4 risk evaluations.

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- I.3.0 Overview of CRARE Technical Approach:

  This section addresses the types and sources of data, site conditions after remediation, and other site-specific information used in the CRARE.

- I.4.0 Contaminants of Concern:

  The COCs are developed in this section. The FS risk assessments were used to develop Operable Unit 1, 2, and 4 COCs. For Operable Units 3 and 5, the COCs were extracted from the SWCR, Appendix R, accounting for postremediation conditions.

- I.5.0 Exposure Scenarios:

  This section defines the components of the exposure scenarios, discusses the steps involved in identifying and developing the scenarios, and covers the screening and selection of those currently identified. Selected exposure scenarios are those that are determined to require a quantitative evaluation of the risk assessment.

- I.6.0 Fate and Transport Modeling:

  This section described the methodology used to quantitatively predict contaminant concentrations at the FEMP. It includes discussions of: 1) the fate and transport models used, 2) their required data and default parameter values, 3) the technical approach that determines the appropriate model for each potential exposure assessment, and 4) model results.

- I.7.0 Toxicity Assessment:

  In this section, a toxicity assessment is presented for a qualitative evaluation of the scientific data to determine the nature and severity of the toxic properties associated with the COCs. The section includes a critical review and interpretation of toxicity data from epidemiological, clinical, and animal in vitro studies, and a quantitative estimation of the amount of exposure to a contaminant that may result in an adverse effect on a biological receptor. This defines the relationship between the dose received by a receptor and the incidence of the adverse effect.

- I.8.0 Quantification of Contaminant Exposure and Intake:

  This section contains a description of the methodology and parameters employed to quantify long-term exposures for significant exposure pathways at the FEMP. This methodology employs the concept of the reasonable maximum exposure (RME), the maximum exposure reasonably expected to occur at the site. If the RME is acceptable, then it is likely that all other, lesser exposures at the site will also be acceptable. To be consistent with ongoing risk assessment work in the FS, the methodology and parameters in this section closely reflect those presented in the RAWPA.

- I.9.0 Risk Characterization:

  Risk characterization is the final step in the CRARE process and involves combining the information developed in the toxicity and exposure assessments. This information is integrated and presented as qualitative and quantitative estimates of health risk. Short-term risks are summarized based on FS reports.

  Potential carcinogenic effects are presented as the probability an individual will develop cancer over a lifetime of exposure, and are characterized by combining estimated intakes and dose-response information.

- I.10.0 Uncertainties:

  This section presents the potential for the CRARE to under- or over-predict risk via a series of assumptions and numerical models.

- I.11.0 Summary of Methodology and Results:

  A summary of methodologies used and the site-wide residual risk by receptor is presented for the current and future postremediation scenarios.

- I.12.0 Conclusions and Recommendations:

  Conclusions about the allocation of residual risk to receptors and scenarios for carcinogenic and noncarcinogenic risk are presented. Recommendations for future CRARE considerations are given.

- I.13.0 References:

  Literature cited is presented in this section.

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I.2.0 OVERVIEW OF INFORMATION BASE AND ASSUMPTIONS

Three types of site-wide data are used in this CRARE: 1) data that characterize the concentration or activity of contaminants, 2) data used to model the fate and transport of constituents, and 3) data used to estimate exposure.

Data generated as a result of the Operable Unit 1, 2, and 4 RI/FS activities are considered primary sources in this CRARE. Data generated in studies of past site operations and non-RI/FS data related to off-property soil, surface water, sediment, groundwater, etc. are considered secondary sources. Primary and secondary data were compared for corroboration. In general, secondary data were used in the CRARE only when primary data were not available.

Nine FEMP documents supplied much of the source data for this CRARE:

- *Fernald Risk Assessment Policies*, 1993 through 1994 (Nelson 1994)
- *Risk Assessment Work Plan Addendum* (Final), June 1992 (DOE 1992i)
- *Site-Wide Characterization Report* (Final), March 1993 (DOE 1993e)
- *Remedial Investigation Report for Operable Unit 1* (Draft), October 1993 (DOE 1993f)
- *Feasibility Study Report for Operable Unit 1* (Draft), November 1993 (DOE 1993g)
- *Remedial Investigation Report for Operable Unit 2* (Draft), January 1994 (DOE 1994a)
- *Feasibility Study Report for Operable Unit 2* (Draft), January 1994 (DOE 1994b)
- *Remedial Investigation Report for Operable Unit 4* (Final), November 1993 (DOE 1993d)
- *Feasibility Study Report for Operable Unit 4* (Final), December 1993 (DOE 1993h)

I.2.1 ASSUMPTIONS

Throughout the course of the CRARE development, numerous factors and assumptions have been employed that have significant bearing on the interpretation of the resultant risk data. Assumptions concerning future site conditions, the completeness of data, future facility management, demographics, materials containment, and risk assessment methods have been addressed. The following assumptions are specific to this version of the CRARE.

Future Site Conditions

- The designs for the on-property disposal facilities follow the concepts described in the SWCR (for Operable Units 3 and 5) and FS reports (for Operable Units 1, 2, and 4).

- Site soil under Operable Unit 5 would be remediated for U-238 to an activity level not exceeding 60 picocuries per gram (pCi/g), based on the expanded trespasser receptor (the recreational user in the SWCR Part III). The value of 60 pCi/g was selected as a target cleanup level and may change as the operable unit FSs are completed.

- The FEMP property boundaries and operable unit boundaries define the source areas for the CRARE analysis. Impacts from non-FEMP off-site contaminants and related contaminant transport, and FEMP off-site disposal locations are not included in this CRARE.

- All volatile organic compounds (VOCs) have been effectively removed to a level no longer warranting air dispersion modeling after remedial action is complete (short-term and long-term adverse impacts are addressed in the Public Health and Occupational Risk Consideration appendix to each operable unit's FS report).

- VOCs and semivolatile organic compounds (SVOCs) would be reduced in the groundwater through the pump and treat operations of Operable Unit 5. This assumption is consistent with the Amended Consent Agreement relative to operable unit definitions. It is considered reasonable based on the low frequency of detection and low concentrations (ppb range) of these compounds, as reported in the SWCR. The SWCR evaluated COC concentrations in 85 off-site wells and identified 7 of them as containing elevated concentrations of VOCs or SVOCs. Five of these are located in the vicinity of the southern property boundary or the South Plume. Two wells are located along the northwestern, up gradient property boundary. Radionuclides are much more widespread in the South Plume and are the major focus of remediation there. Groundwater that is removed from the South Plume for treatment will eventually be discharged to the Great Miami River and not returned to the aquifer. It is probable that this process will reduce the existing VOC and SVOC concentrations to minimal levels as part of the effort to remediate the more extensive radionuclide contamination.

- The CRARE Site-Wide Conceptual Model describes site conditions immediately following and for up to 1000 years after remediation. The three land use scenarios are summarized in Section I.1.6 and detailed in Section I.5.0.

- The contaminated surface soils would be remediated to the cleanup levels for all contaminants of concern (COCs) which exceed those levels.

- The surface soil not covered by caps is assumed to be 85 percent vegetated per Appendix E (Fate and Transport Modeling) of the Operable Unit 4 RI report.

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Completeness of Data

- All "hot spots" (areas where COC concentrations exceed cleanup levels) have been identified as a result of sampling to date.

- All COCs considered for Operable Units 1, 2, and 4 are identified in the RI and FS reports for those units.

- COCs considered for Operable Units 3 and 5 are identified in Appendix R of the SWCR.

- The nature and extent of contamination for Operable Units 1, 2 and 4 are described in the RI reports for those units.

- The nature and extent of contamination for Operable Units 3 and 5 are described by the data contained in the SWCR and RI/FS database, as of March 1993. This database may contain nonvalidated data, which may have been used in this CRARE as the best available data.

- Physical properties used for groundwater transport modeling were taken from fate and transport modeling assumptions contained in the RI/FS reports as well as the SWCR. It is recognized that these are important parameters and efforts are underway to verify the understanding of the groundwater system.

Future Facility Management

- For the Current Land Use scenario, maintenance would be performed on the fences, facility and storage areas for 70 years after remediation. The necessity and duration of this maintenance would be considered in future assessments.

- The government would own the FEMP for up to 1000 years under the Future Land Use With Federal Ownership scenario, and therefore will control land use to prohibit residences, farms, or any public land use.

- Under the Future Land Use Without Federal Ownership scenario, the FEMP would revert to private ownership and would become a resident farm immediately after the remediation is complete. No further maintenance or control would occur for the 1000-year evaluation period.

Socioeconomics

- During the 1000-year evaluation period, the surrounding land use will remain primarily agricultural.

- Population density changes for the 1000-year evaluation period are assumed to be insignificant.

Demographics

- For the CRARE, the off-site resident farmer is located at the point of maximum exposure (on the fence line) for both air and groundwater COC modeling. Predicting the actual location of populations 1000 years into the future is acknowledged to be highly speculative. However, even if the FEMP were surrounded by residential housing, the risk would be no greater than that of the resident farmer, because a farmer's exposure would exceed that of a resident. Note that the CRARE methodology is designed to assess site-wide exposure to the RME individual and is not conducive to the assessment of collective or population risks.

Material Containment

- All material left on-property, not including soils left in place, would be contained in permanent on-property disposal facilities or in capped or covered areas for the duration of the 1000-year evaluation period.

- Soils would either be washed, capped, contained, or removed to meet cleanup levels.

- Containment structures would be effective for a period of not less than 1000 years in preventing direct contact with disposed materials.

- Containment structures may leak and seep during the period immediately following remediation for up to 1000 years after remediation. Anticipated moisture infiltration rates through the on-property disposal facilities are presented in Section I.6.1.3.3.

- The surface caps would use a design that would function effectively for 1000 years.

- Caps are assumed to meet Ohio state regulations as stipulated in OAC 3745.

Risk Assessment Methods

- The RAECOM model for estimating radon emissions from soil is considered to be conservative.

- Contaminants adsorbed to soils in runoff remain adsorbed in the stream sediment.

- Contaminants dissolved in runoff water remain in the water column in the receiving stream.

- Inputs from individual source areas can be summed to obtain site-wide inputs to receiving streams.

- This CRARE addresses long-term residual risks associated with the remediated FEMP site. Short-term risks, such as those related to remediation activities, are taken from the information in the Operable Unit 1, 2 and 4 FS reports.

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- This CRARE addresses human health risks. A quantitative site-wide ecological risk assessment will be performed as part of the Operable Unit 5 RI in accordance with the Amended Consent Agreement.

- Some groundwater COCs (Section I.4.0) have been eliminated from quantitative risk assessment by transport screening calculations of contaminants in the vadose zone.

- This CRARE uses the LRAs for Operable Units 3 and 5 as identified in the SWCR, and the PRAs for Operable Units 1, 2, and 4 from their FS reports.

- New reference doses (RfDs) and cancer slope factors will not be developed as part of the CRAREs. Those values developed for the Operable Unit 1 and 2 RI reports have been applied.

- Exposure parameters are taken from the values published in the Operable Unit 2 RI report and are presented in Section I.8.0.

- Validated data are the primary source of exposure concentration estimates. Where validated data are not available, the highest detected concentration of a contaminant in a medium may be used.

- Based on the site operational history, it is assumed that 90 percent of the chromium that has been identified is not hexavalent; therefore, 10 percent would be carried over as hexavalent in the risk assessment. The rationale for the health-hazard approach used for chromium is presented in Section I.7.0. The associated uncertainties are discussed in Section I.10.0.

- Lifetime cancer risk was calculated for external exposure to gamma-emitting radionuclides in contaminated surface soil, sediments, and airborne particulates.

I.2.2 REMEDIAL ALTERNATIVES

This section summarizes the PRAs for Operable Units 1, 2, and 4, which have been updated using the FS reports for those units. For Operable Units 3 and 5 (whose FS activities have not yet been completed) the LRAs may be changed in the future to represent updated plans. With the development of new field data and new approaches to remediation, major changes may be expected for some of the operable unit remedial alternatives. While the remedial alternatives do not redefine the cleanup levels, they do indicate what level of cleanup the remedial technologies can possibly achieve. Changes to the Operable Unit 3 and 5 LRAs, therefore, may result in significant changes to future CRARE transport modeling and risk assessment. Figure I.2-1 has been provided to illustrate postremediation site conditions as projected based on the PRA/LRAs presented below.

I.2.2.1 Operable Unit 1 PRA

Operable Unit 1 includes Waste Pits 1 through 6, the Burn Pit, and the Clearwell. Soil between the pits and contaminated soil adjacent to the boundary of Operable Unit 1 are also included, as is perched groundwater within the waste pit area. The Burn Pit and Pits 1, 2, 3, and 6 contain hazardous constituents and radiological substances. The Clearwell and Pits 4 and 5 contain a mixture of radiological and hazardous waste.

The PRA for Operable Unit 1 includes removal, pretreatment drying and off-property disposal of waste pit materials, caps, liners, and contaminated soils, backfilling of excavated areas with clean soil, and construction of a cover system with an infiltration limiting layer. Remaining Operable Unit 1 contaminated residual soils will be dispositioned per the Operable Unit 5 ROD.

I.2.2.2 Operable Unit 2 PRA

Operable Unit 2 includes the Flyash Piles and other South Field disposal areas, the Lime Sludge Ponds, Solid-Waste Landfill, berms, perched groundwater, liners, and soil within the operable unit boundary. The PRA for the specific subunits found in Operable Unit 2 are presented below.

Active Flyash Pile. Contaminated materials above cleanup levels would be consolidated into the northern portion of the South Field. A clay cap will be constructed over these materials and adjacent to the South Field and Inactive Flyash Pile composite cap. Subsurface, lateral groundwater drainage will be collected and treated.

Lime Sludge Ponds. The current PRA consists of consolidation and containment of contaminated materials and lime sludge from the Lime Sludge Pond area and the K-65 Slurry Lime Trench. These consolidated materials will then be contained under a composite cap.

Solid-Waste Landfill. The Solid-Waste Landfill includes one area that is contaminated to higher levels of activity and to greater depths below ground surface than the remainder of the landfill. This has resulted in contamination of the perched water beneath the landfill. The PRA for this subunit involves excavation, consolidation, and containment under a composite cap. Any excavated area created by consolidation would be filled and regraded, and excavated materials would be consolidated within the landfill and covered with a composite cap.

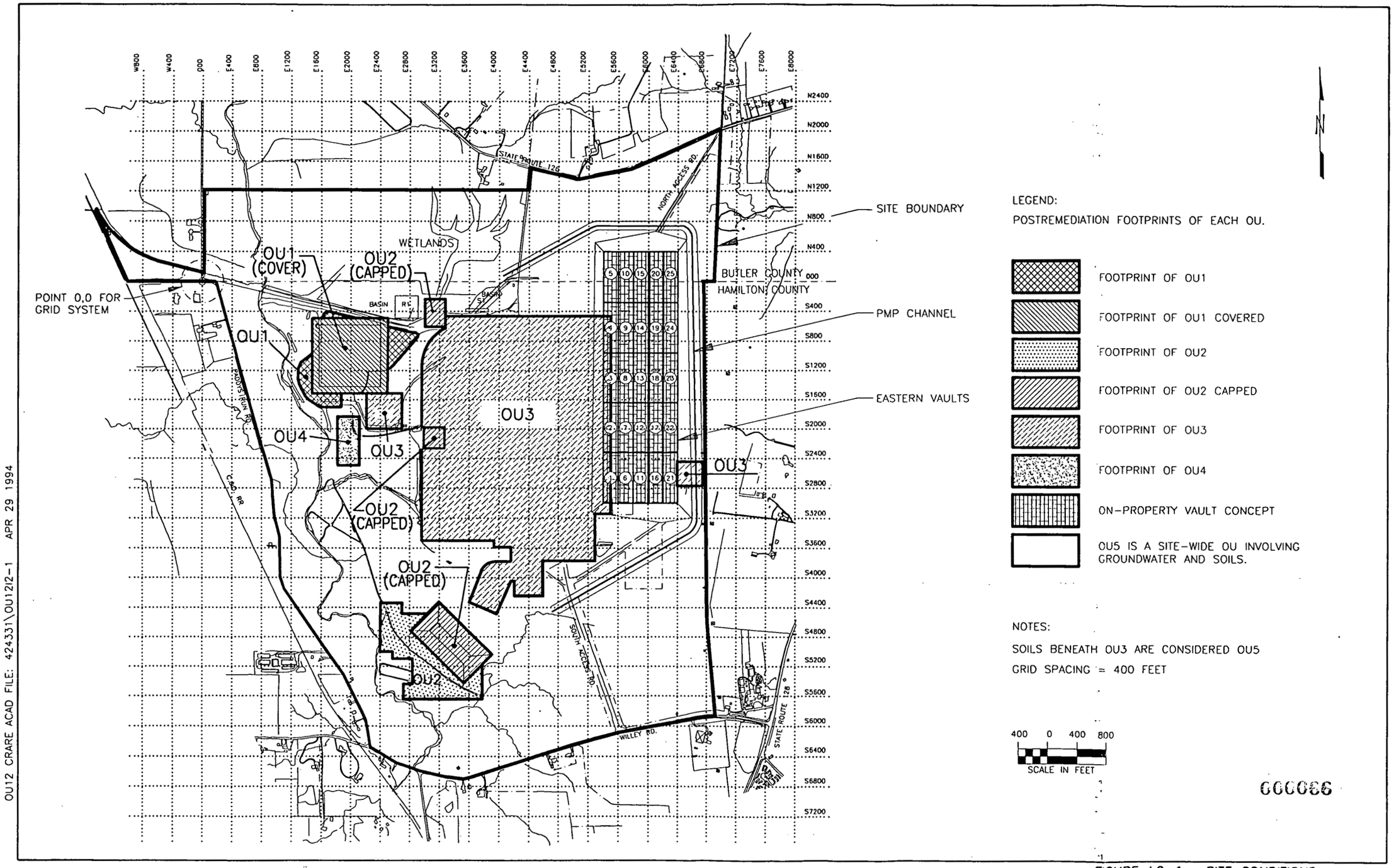

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FIGURE 1.2-1 SITE CONDITIONS, POSTREMEDIATION

South Field. The South Field has been identified as a source of contamination for the GMA. Soil and materials contaminated above cleanup levels would be excavated and consolidated in the northeastern portion of this Operable Unit 2 subunit. The excavated areas would be regraded, and a composite cap would be placed over the consolidated material. The lateral drainage of perched groundwater would be collected and treated throughout the Current Land Use Scenario.

Inactive Flyash Pile. The proposed remediation approach includes excavating and consolidating the material contaminated above cleanup levels. A composite cap would be constructed over the consolidated material in the northern portion of the South Field. An interceptor trench would be constructed in the Inactive Flyash Pile area to collect perched groundwater. The excavated areas of the Inactive Flyash Pile would be backfilled with clean fill and planted with vegetation.

I.2.2.3 Operable Unit 3 LRA

Operable Unit 3 consists of the former production area and associated facilities and equipment. It incorporates all above- and below-grade improvements, including all structures, equipment, utilities, drums, tanks, solid waste, waste product, effluent lines, the K-65 transfer line, wastewater treatment facilities, fire training facilities, scrap metal piles, feed stocks, and the coal pile. The production area occupies about 55 hectares (136 acres) near the center of the FEMP and contains many buildings, scrap metal and soil piles, material containers, storage pads, a parking lot, roads, railroad tracks, and above- and underground tanks, utilities, and equipment. Several impoundments, ponds, and basins are also included.

For the Operable Unit 3 LRA, contaminated material would be removed, treated and/or decontaminated, temporarily placed in storage, and finally disposed to reduce the potential for contaminant migration. Decontamination and treatment residue would require further treatment and disposal. Contaminated material would be disposed in the vaults while clean material would be free-released for reuse or recycling.

I.2.2.4 Operable Unit 4 PRA

Operable Unit 4 includes the structures and stored waste of Silos 1, 2, 3, and 4; the soil berms surrounding Silos 1 and 2, the decant tank, its contents and associated piping; the existing radon treatment system; and any contaminated subsoil underlying the silos.

The PRA for Operable Unit 4 includes removing the waste stored in Silos 1, 2, and 3, stabilized it via vitrification, and removing it to an off-property disposal facility. Silos 1, 2, 3 and 4 will be decontaminated to the extent practical and demolished. Contaminated soil and construction material from the silo berms, subsoil, and decant tank would be removed to the extent necessary based on cleanup levels and temporarily stored on-property for eventual treatment and disposal with Operable Unit 3 debris and/or Operable Unit 5 soil. These actions are presented in the Proposed Plan For Remedial Actions at Operable Unit 4 (DOE 1994d).

I.2.2.5 Operable Unit 5 LRA

Operable Unit 5 includes groundwater, surface water, soil, sediments, flora, and fauna not included in Operable Units 1 through 4.

Under the LRA for Operable Unit 5, contaminated groundwater would be extracted, treated at an on-property facility, and discharged to the Great Miami River through the newly constructed effluent line. Treatment residuals would be disposed in on-property disposal facilities. The LRA also involves excavating contaminated sediment and soil necessary to meet cleanup levels transporting the contaminated material to an on-property location for treatment using soil-washing, and returning the treated material as backfill. For U-238, a 60-pCi/g target cleanup level was selected. This cleanup level and those for other COCs were defined in the SWCR. The soil-washing fluids would be recycled and the removed contaminants stabilized and disposed in on-property disposal facilities.

I.2.3 ON-PROPERTY DISPOSAL FACILITY DESIGN

As part of the RI/FS process, CERCLA requires that remedial alternatives be developed and evaluated. For the FEMP, the RI/FS documentation for each operable unit provides the recommendation of the most appropriate alternatives. Initial Screening of Alternatives reports have also been prepared for Operable Units 1, 2, 4, and 5 identifying the remedial alternatives for each operable unit. In each case, an on-site disposal option has been included, under which some wastes or treated materials would be disposed in on-property disposal facilities. Several disposal facility designs have been developed for on-property disposal of FEMP contaminants. This CRARE assumes that the structures and debris from Operable Unit 3 (including the silos from Operable Unit 4) would be placed in sealed concrete vaults covered with an engineered cap. The

excavated soil and material from Operable Unit 2 would be consolidated and capped. In addition, the Solid-Waste Landfill would be closed in place and capped.

The following discussions describe the major features of the disposal facility and cap designs assumed for this CRARE. Other alternatives, such as in-situ remediation and off-property disposal, will be identified and possibly implemented as part of the RI/FS process for each operable unit. Accordingly, the disposal facility and cap designs may change.

I.2.3.1 Vault Description

Twenty-five vaults would provide long-term, on-property disposal of the radioactive, hazardous, and mixed waste generated during the FEMP remediation. The vaults would accommodate the different waste types, volumes, and generation rates for Operable Units 3 and 5, as noted in the SWCR. In addition, Operable Unit 4 materials will be stored in the vault, based on the Operable Unit 4 Proposed Plan.

There are two design concepts for the vaults. The wet vault would accept waste in the form of a grout slurry that would solidify in the vault. The dry vault would accept waste in discrete containers. The structure of the wet and dry vaults is essentially the same, except that the wet vaults have access panels in their roofs through which slurry can be placed. Figure I.2-2 presents a typical vault system, showing both wet and dry vaults.

For the wet vaults, access panels would be provided through the concrete roof to allow the grout to be placed and inspected. For the dry vaults, a service opening would be provided for each disposal cell along one side of the vault to allow access for placing the containers. A forklift would be used to stack waste containers in the cells of the dry vaults. Active disposal cells would be ventilated to remove exhaust gases.

The vaults would be located on FEMP property near the eastern perimeter. Each vault would consist of an above-grade, reinforced concrete structure capable of storing approximately 68,814 cubic meters (90,000 cubic yards) of waste. The floors and roofs of the vaults would be sloped. To facilitate leachate collection and leak detection, the vaults would contain 3 modules each, with 4 cells in each module, for a total of 12 cells per vault. One vault would have only two modules

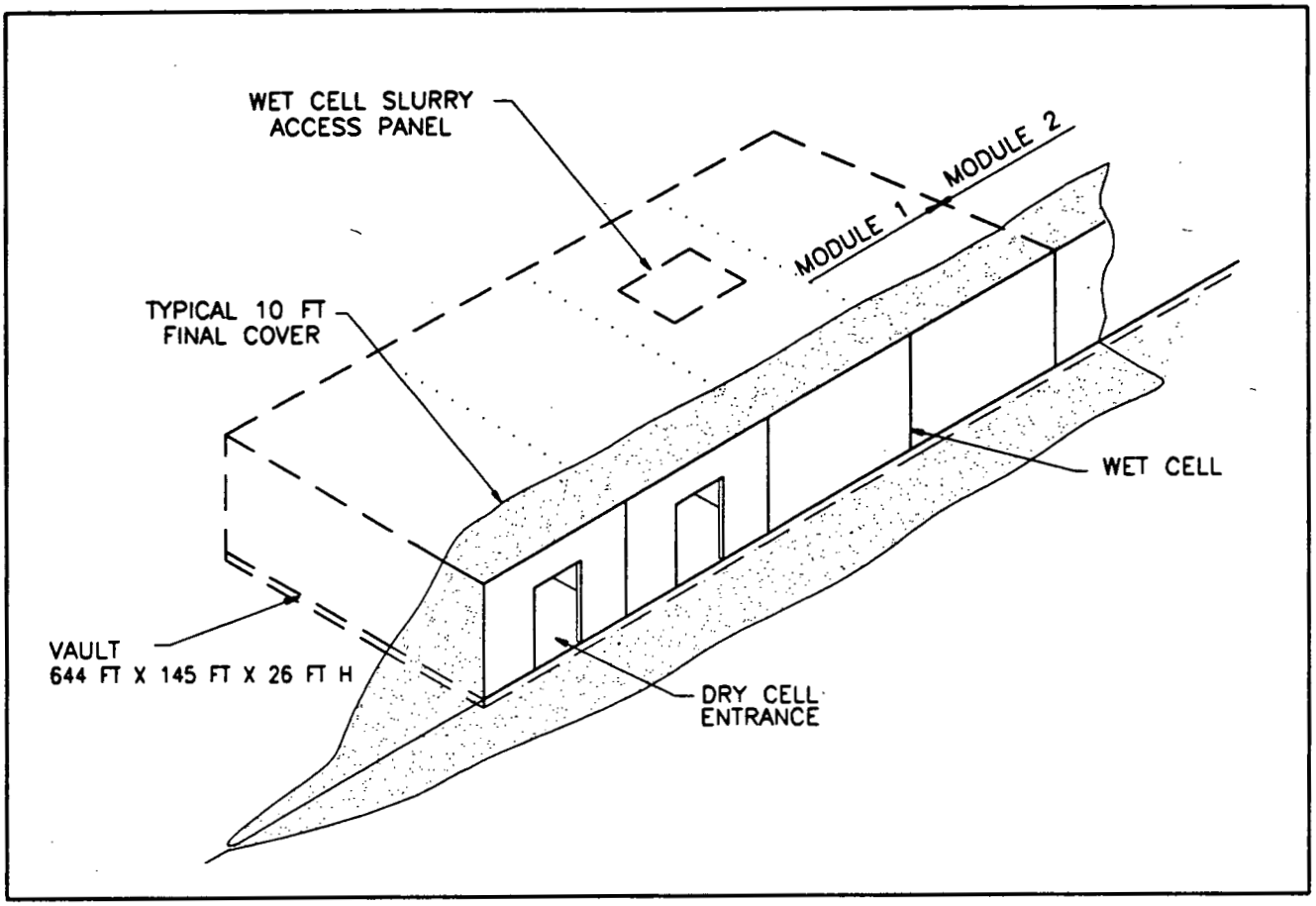

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FIGURE I.2-2

TYPICAL VAULT

and eight cells. Each disposal cell would contain a double liner system with leachate collection and leak detection capability. The liners selected would be chemically resistant to waste and leachate.

A HDPE sump and tank system would be used to collect and detect leachate. Each cell would have its own leak detection sump. The leachate collection and leak detection systems would both have piping that extends to the surface. This piping would provide access for instrumentation, pump-out, and cleaning of the tanks, sumps, and pipes. The leak detection systems would be routed to the facility support building. When a final cover is placed over the vault, manways would be installed from the final grade down to the top of the vault base slab surface.

Vault access roads would be provided for both construction and operations service traffic. The roads would have two lanes: one for an unloading zone on the cell service entrance side of the

vault, the other lane for through traffic. Access to each vault would be from aprons in front of the service entrance of each cell. These aprons would provide a staging area for unloading and transferring treated waste material into the dry vault cells, or a staging area for the wet vault slurry transfer system. Access roads adjacent to the vaults would be removed during final closure.

After filling a vault to capacity, interim closure would be performed. This consists of removing all temporary structures and sealing all vault openings. An engineered cover, consisting of compacted soil, gravel, cobblestone, sand, clay, and a synthetic liner material, would be placed over the vault. The cover would be designed to withstand estimated settlements and provide a long-term barrier. The cobblestone layer would act as an intruder barrier. The surface of the final cover would be sloped to promote drainage away from the vault. The permeability of the cover would be no greater than that of the bottom liner and would be less than 10^{-7} centimeters per second. The cover system would have a minimum thickness of 5 meters (16.4 feet) or have an intruder barrier.

During the placement of waste in the cells, gases would be vented using temporary removal systems. Upon closure, all temporary vent systems would be removed. The vaults would not contain a permanent venting system.

During remediation and for a 70-year period after remediation, if the Current Land Use scenario is implemented (with access controls), storm water runoff from the waste disposal operation areas, including the vaults, would be controlled by drainage ditches, culverts, sedimentation and retention basins, and lift stations. The system would be designed to handle peak discharge from a 24-hour, 25-year storm. To maintain the design capacity, provisions would be included to empty the storm water accumulating in the retention basin. The accumulated water would be pumped to a waste water treatment facility for treatment prior to discharge. Storm water runoff from closed and unregulated areas would be allowed to flow off-property via man-made and natural water courses. Erosion structures would be used, if required. Under the Future Land Use scenarios, all retention basins are breeched and non-operative.

I.2.3.2 Cap and Cover System Design

The caps would have a 1000-year design life that minimizes the release of contaminants to air and groundwater. This approach is included in the PRA for Operable Unit 2 and is evaluated in the Operable Unit 2 FS report.

A cover system will be constructed over Operable Unit 1. This cover will consist of compacted fill with an infiltration limiting layer of clay which in turn will be covered by vegetated topsoil. This is described as the PRA in the Operable Unit 1 FS report.

Figure I.2-3 presents the composite cap for the Inactive Flyash Pile, Lime Sludge Ponds, Solid-Waste landfill and contaminated materials from the South Field. The cap will consist of 0.15 meters (0.5 feet) of vegetated topsoil, 0.53 meters (1.75 feet) of common soil, a layer of geotextile fabric, 0.15 meters (0.5 feet) of sand filter, another layer of geotextile fabric, 0.91 meters (3 feet) of cobbles, a layer of geotextile fabric, 0.30 meters (1 foot) of pea gravel, a layer of Bentonite Geocomposite, a 0.61-meter (2-foot) clay soil liner with bentonite, and 0.30 to 0.61 meters (1 to 2 feet) of compacted fill.

The design of the clay cap is presented in Figure I.2-4. The cap will consist of 0.15 meters (0.5 feet) of vegetated topsoil, 0.46 meters (1.5 feet) of common soil, a geotextile fabric, 0.30 meters (1 foot) of pea gravel, a geotextile fabric, 0.61 meters (2 feet) of compacted clay soil liner, and 0.30 to 0.61 meters (1 to 2 feet) of compacted fill.

Essentially, the evaluation of the caps in the CRARE provide for a low- to no-maintenance design. For each operable unit for which a cap is proposed in the CRARE, the feasibility of using it would be specifically evaluated in that unit's FS.

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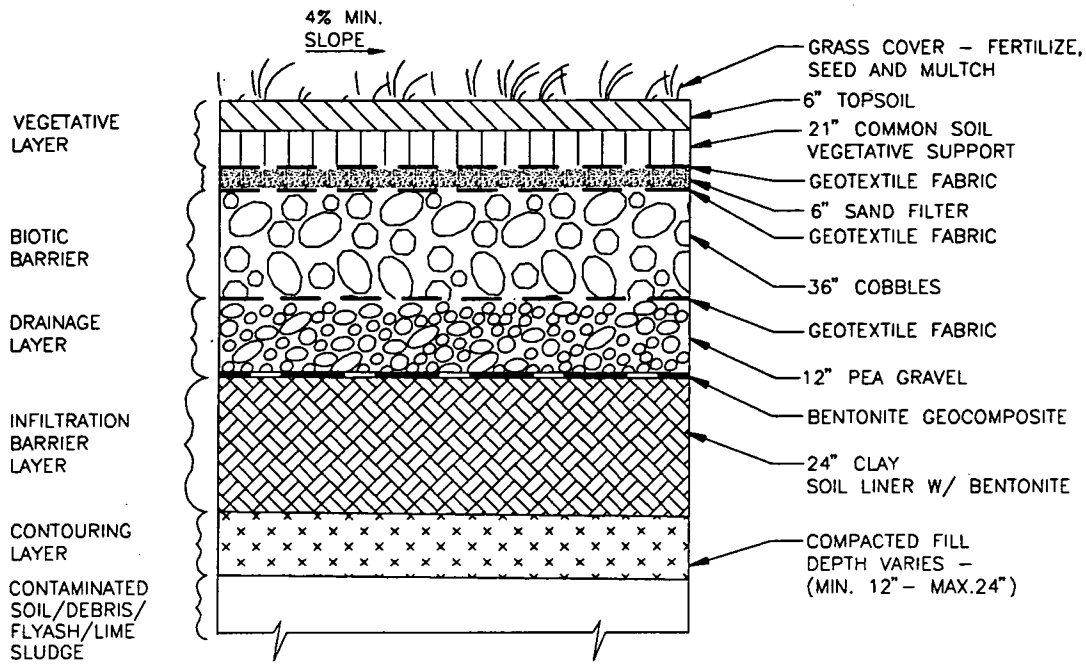


COMPOSITE CAP

LEGEND

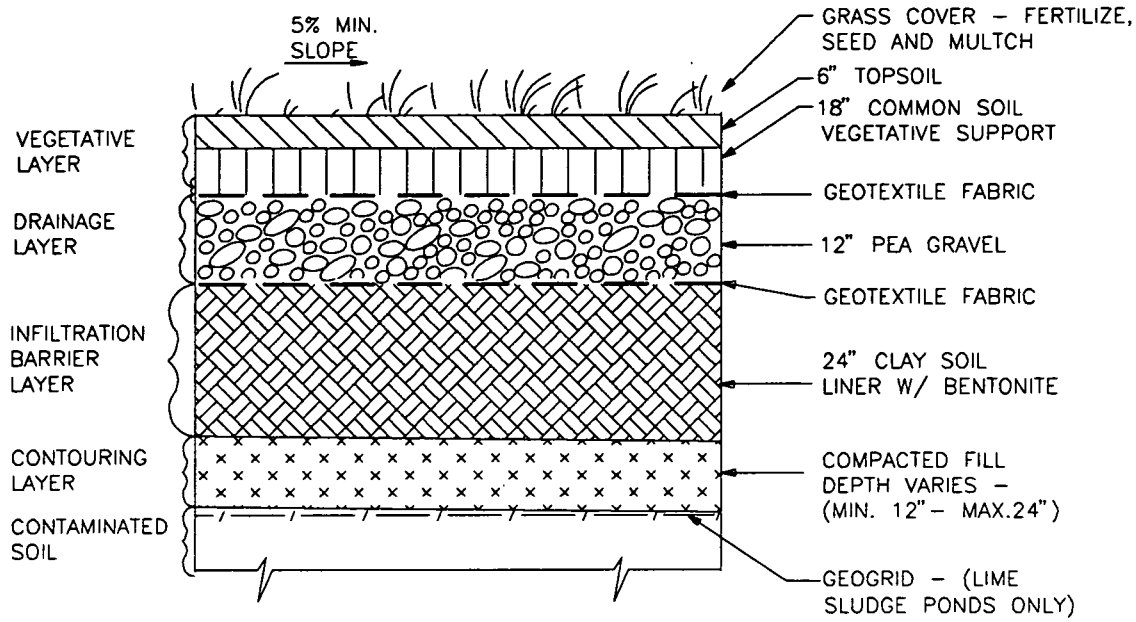
- GRASS COVER
- TOPSOIL
- VEGETATIVE SUPPORT
- SAND
- COBBLES
- PEA GRAVEL
- CLAY SOIL LINER W/ BENTONITE
- CONTOUR FILL
- GEOTEXTILE FABRIC
- BENTONITE GEOCOMPOSITE

000073

Source: OU2 FS Report (DOE 1994b)

OU12 CRARE CADFILE: 424331\OU12I2-3 APR 29 1994

FIGURE 1.2-3
TYPICAL SECTION
COMPOSITE CAP



CLAY CAP

LEGEND

- TOPSOIL
- VEGETATIVE SUPPORT
- PEA GRAVEL
- CLAY SOIL LINER W/ BENTONITE
- CONTOUR FILL
- GRASS COVER
- GEOTEXTILE FABRIC
- GEOGRID (LIME SLUDGE PONDS ONLY)

Source: OU2 FS Report (DOE 1994b)

OU12 CRARE CADFILE: 424331\OU12I2-4 APR 29 1994

FIGURE 1.2-4
TYPICAL SECTION
CLAY CAP

I.3.0 OVERVIEW OF CRARE TECHNICAL APPROACH

This CRARE is based on projected site conditions after remediation has been completed. In the baseline risk assessment, actual site conditions, including contaminant concentrations, are used with modeling to project concentrations, exposures, and risks to various receptors. For the CRARE, initial conditions are determined from the result of treatment and disposal alternatives described in each operable unit FS or the SWCR. Modeling must then be used to determine future concentrations, exposures, and risks to receptors under various land use scenarios.

Groundwater fate and transport modeling was used as part of the CRARE methodology to predict future COC concentrations in groundwater resulting from migrations from residual soil contamination and the on-site disposal facilities. Future ambient air concentrations were predicted from air pathway transport modeling of soil and disposal area sources. Direct exposure (through air, soil, surface water, and groundwater pathways) and indirect exposure (via food pathways) from soils and water were modeled using projected soil and water contaminant concentrations. All of this was based on site physical conditions, topography, etc. projected from engineering estimates of the impact of the remedial alternatives. This section summarizes the CRARE methodology. Sections I.4.0 through I.7.0 should be consulted for a detailed description.

I.3.1 CRARE TECHNICAL APPROACH

The methodology used in the CRARE is consistent with the Amended Consent Agreement, which states: "The cumulative residual risk contributions from the other operable units will be estimated based upon the selected alternative, or the Leading Remedial Alternative." In addition, the RAWPA states that a residual risk assessment will be performed after all RODs have been finalized. The Addendum emphasizes the iterative nature of cleanup level selection. The CRARE does not select cleanup levels, but rather reports the risks calculated using the cleanup levels from each operable unit. The overall technical approach for the CRARE has been developed within the context of the RI/FS process for the FEMP to determine if the remedial alternatives for the operable units protect human health and the environment or, if they do not, to provide information useful in developing the best path forward.

This CRARE has been prepared in conjunction with the EPA, OEPA, and DOE guidelines to assess the potential risk of exposure to radionuclides and hazardous chemicals. It follows the methodology presented in the RAWPA, which derived much of its methodology from the EPA Risk Assessment Guidance for Superfund (RAGS). However, deviations to the methodology discussed in the RAWPA are the result of: 1) FERMCO's response to EPA Region V review comments on the SWCR and Operable Unit 1 and 4 RI reports, 2) the release of additional guidance documents after the submittal of the Addendum and the SWCR, and 3) technical information attained from literature other than that cited in the Addendum and SWCR. These deviations are summarized below.

- Groundwater cleanup levels for radionuclides were developed from a 10^{-6} target risk level and from applicable, relevant, and appropriate requirements (ARARs) and those to be considered (TBC). The ARARs/TBCs include maximum contaminant levels (MCLs) and proposed MCLs. In addition, the 4 mrem/year MCL for man-made beta and gamma emitters was interpreted to apply to alpha emitters. In this instance, cleanup levels were calculated using committed effective dose equivalents to a 4 mrem/year intake, assuming a drinking water rate of 730 l/year, and using dose conversion factors from EPA's Federal Guidance Report (EPA 1988g).

- Cleanup levels have previously been calculated for on-property farmers, expanded trespassers, and off-property farmers. Values for the expanded trespasser receptors were calculated using both a 10^{-6} target risk and a 100 mrem dose limit from 10 CFR 20, for allowable exposures to the general public.

- The soil ingestion rate for the on- and off-property resident farm adult was increased. The new rate of soil ingestion, 0.18g/day, was developed in response to EPA comments on the SWCR. This soil ingestion rate was based upon a standard adult soil ingestion rate of 100 mg/day and modified to account for farming activities (February 11, 1993 FERMCO memo). The derivation of the 180 mg/day soil ingestion rate is presented in detail in the Operable Unit 4 RI report (DOE 1993d).

- Skin surface area available for contact was increased for the child and adult receptors to comply with guidance from EPA, Region V. This change reflects better characterization of the receptor's physical parameters and the availability of new data in the literature.

In addition to the Operable Unit 1, 2 and 4 FS reports, information for this CRARE has been extracted from the SWCR for the other operable units. This CRARE reflects the Risk Information Data Quality Objectives and is sensitive to EPA's comments on the Operable Unit 1, 2 and 4 RI reports and the SWCR. Additionally, this CRARE uses the groundwater fate and transport modeling concepts developed for Operable Unit 5.

I.3.2 FATE AND TRANSPORT MODELING OF RESIDUAL CONTAMINANTS

Section I.1.6 describes the CRARE Site-Wide Conceptual Model, which was used to establish potential sources, pathways, and contaminant receptors. Section I.2.1 discusses the major assumptions used to estimate conditions. After developing the conceptual model, fate and transport computer models were used to simulate the transport processes. A discussion of the computer models follows.

I.3.2.1 Groundwater and Surface Water Modeling

The SWCR (Section II, Part 3.2.1) describes the development of specific conceptual models for source terms, release mechanisms, and receptors, and the selection of numerical computer codes for RI/FS work at the FEMP. The CRARE fate and transport models use the same approaches and codes where appropriate. The principal differences between the baseline and CRARE numerical models are in the definition of source terms from the respective conceptual models. The same One-Dimensional Analytical Solute Transport (ODAST) and SWIFT III codes were used to model transport through the vadose zone and the aquifer, respectively. More detailed descriptions of ODAST and SWIFT III are presented in Section I.6.1.

The first step in defining source terms for groundwater numerical modeling is to establish the COCs to be evaluated in the assessment. Section I.4.0 describes how a site-wide list of potential COCs was compiled for possible inclusion in the CRARE and then reduced through three screening procedures. Additional screening of the COC list for the groundwater pathway was then done (Section I.6.1) to remove those COCs from the list that are predicted to not be transported in significant quantities by ODAST through the vadose zone within 1000 years.

As defined in Section I.6.1, the source terms for the various areas of the site are the leachate from the vaults, the residual soil, and the capped/covered areas. The ODAST results for these areas were used as direct inputs to the CRARE SWIFT III groundwater model.

Engineering studies of the vaults and capped/covered areas have been completed that estimate leakage rates through the structures over time. Preliminary Toxicity Characteristic Leaching Procedures (TCLPs) were performed on various types of waste that would be stored on the FEMP. The results were used to estimate the contaminant concentrations in the leachate and

then used as input to the ODAST model to estimate transport through the vadose zone. TCLP results were not available for all types of waste. Geochemical modeling or literature values were used to estimate leachate concentrations where the TCLP results were not available.

For soil that is excavated, treated, and returned as backfill, U-238 was assumed to be at a concentration of 60 pCi/g and Ra-226 at 5 pCi/g. Untreated residual soil was assumed to retain its current level of constituents. Geochemical modeling or literature values were used to estimate leachate concentrations from contaminated soil, and the HELP model was used to estimate infiltration and runoff values for surface soil.

A simplified analytical approach was used to estimate runoff and contaminant transport from surface soils to Paddys Run. The flow in Paddys Run was used as a source term for groundwater in downstream areas where it recharges through coarse sediments. The ODAST model was not used in these areas.

For all source terms, the total mass of available contaminants was initially estimated for the start of the model time frame. As contaminants were transported away or decayed over time, these source masses were depleted. If they were exhausted before completion of the 1000-year simulation, then the source was deleted from that time forward.

The flow and contaminant concentration data from all of the ODAST simulations were used by the SWIFT III model to calculate mass loadings of contaminants to groundwater. Other general groundwater flow conditions were established previously in the SWCR. SWIFT III predicted the transport of the contaminants in the groundwater flow paths and developed contaminant concentration contours at specified times. From this data, specific receptor locations were selected as representative of the maximum potential risks to on- and off-property residents. Plots of concentration versus time for these locations were then developed to estimate the potential risks from groundwater contaminants originating at the FEMP.

I.3.2.2 Site-Wide Air Pathway Analysis

The objectives of the air quality impact analysis were to calculate the risk from estimated ground-level air contaminant concentrations from the PRAs or LRAs. The ground-level air contaminant concentrations were then used in the exposure analysis.

Air Emission and Dispersion Modeling

Air dispersion modeling conducted for risk assessment calculations used an EPA air quality dispersion model, the Industrial Source Complex, Long-Term, Version 2 (ISCLT2). Rn-222 emission rates were estimated using the RAECOM model, which converts Ra-226 soil concentrations to Rn-222 emission rates, consistent with the natural decay of Ra-226. Airborne particulate emission rates were estimated using methods presented in *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites* (EPA 1985d). Only nonvolatile organic compounds were assumed to remain on-property after remediation; therefore, nonvolatile organic compound soil concentrations were used to analyze organic emission rates.

Sources

The air emissions from the LRAs for Operable Units 3 and 5 (identified in the SWCR) and the PRAs for Operable Units 1, 2 and 4 (identified in their FS reports) were modeled as source areas for risk assessment calculations. Operable Unit 1 has 20 sources; Operable Unit 2, 65 sources; Operable Unit 4, 10 sources; and Operable Units 3 and 5, 436 sources; for a total of 531 source areas. As shown in the Operable Unit 4 CRARE (DOE 1993i), the difference between current and future source terms is trivial. Therefore, only the future scenario source terms are analyzed in this CRARE. More specific information about these sources appears in Section I.6.2.

As indicated above, various 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 nonvolatile organic compounds.

Contaminant Concentrations

Contaminant soil concentrations for Operable Units 1, 2, and 4 were obtained from their RI/FS reports, and for Operable Units 3 and 5 from the SWCR.

The SWCR and the existing sampling database were used to estimate soil contaminant concentrations for Operable Unit 3. These reports were also used to estimate the Ra-226 concentration for waste disposed in on-property disposal facilities. The cleanup levels were used as concentration estimates for remediated soils, consistent with the groundwater modeling approaches presented in Section I.3.2.1.

Meteorological Data

Five years of meteorological data from the FEMP, in stability array (STAR) format, were used to model air quality impacts (1987, 88, 89, 91, and 92). The data collection efficiency for 1990 was below 90 percent and therefore was not used.

Receptors

Air contaminant concentrations were modeled using a receptor grid, a system of fenceline receptors, and several discrete receptors. The receptor grid consists of 985 receptor points covering the site and extending approximately 300 meters (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 impact location was determined from modeled results at the receptor grid points. The on-property residential and occupational worker exposures were developed from the grid point concentration values.

The fenceline receptor system consists of 36 receptor points located around the FEMP at 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).

Discrete receptors included the Elda School and Ross High School in Ross, and the Crosby Township Elementary School between Fernald and New Haven. These receptors were used to determine impacts at sensitive receptors in the surrounding community.

I.3.3 EXPOSURE AND INTAKE ASSESSMENT

Exposure assessment evaluates the amount of contaminants a potential receptor may experience from contact with FEMP residual contaminants and how much would be taken into the body to cause adverse effects. The exposure assessment involves four stages:

1. Characterization of the exposure setting
2. Identification of contaminant migration and receptor exposure pathways
3. Quantification of exposure
4. Assessment of contaminant intake doses

Section I.5.1 provides a detailed description of the exposure setting up to 1000 years after site remediation. Sections I.5.2 and I.5.3 characterize and identify the pathways in which site residual contaminants could reach human receptors. Section I.8.0 contains detailed presentations of the intake equations, data values, and sources of data used in the exposure assessment.

The exposure assessment data in this CRARE were selected according to the following hierarchy (in descending order of preference):

1. Site-specific data obtained from the site remediation database
2. RI/FS database and other regional and site-specific data from studies that complement the RI/FS characterization process
3. Generic exposure assessment data from EPA reference documents
4. Generic exposure assessment data from secondary sources, subject to EPA approval.

I.4.0 CONTAMINANTS OF CONCERN

The principal radioactive constituents found in environmental media at the FEMP are uranium, radium, strontium, technetium, thorium, and their progeny. Principal hazardous waste constituents include heavy metals, chlorinated and non-chlorinated solvents, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). The source areas of the nonradioactive constituents are typically smaller than those of the radioactive constituents.

I.4.1 COMPARISON OF LISTS

A listing of site-wide COCs is presented in Appendix R of the SWCR. The list contains potential COCs, in the various media, that may be present at the FEMP. The SWCR list, which is based on detection in on-property samples, was combined with the lists of potential COCs from the RI/FS reports of Operable Units 1, 2, and 4 to provide a new list, which was then used for the initial screening of COCs in this CRARE. Because the COCs for Operable Units 3 and 5 were obtained solely from the SWCR, it is important to note that SWCR data are subject to validation and may be supplemented by future sampling and data validation in these operable units.

I.4.2 COC SELECTION PROCESS

It was assumed that constituents evaluated in the CRARE are all COCs, since COC selection has occurred as part of the RIs and FSs. Because the CRARE addresses postremediation time frames, total potential COCs have been reduced to reflect the screening in both the RI and FS. Further, some contaminants will have been removed, treated or contained in the future such that exposure to humans and the environment is precluded. For this CRARE, the new site-wide list was screened three times as follows to eliminate contaminants that pose little or no risk to postremediation receptors:

1. Initial screening:

   Eliminate nontoxic compounds, nutrients, laboratory artifacts, and noncompound-specific analytical results.

2. Second screening:

   Eliminate contaminants with vapor pressures above 10 millimeters (0.4 inches) of mercury at 20°C (68°F).

3. Final screening:

   Eliminate contaminants that would degrade sufficiently, based on their organic degradation rates in soil over time, or would be removed from the groundwater by pump and treat operations.

The COC selection process for the CRAREs is illustrated in Figure I.4-1.

I.4.3 INITIAL SCREENING OF COCs

Four criteria were used during the initial screening to eliminate COCs from the initial lists:

1. Contaminant is a nontoxic, ubiquitous compound.
2. Contaminant is detected in blanks associated with the site-related samples at sufficient levels (i.e., at or above the in-situ sample level) to indicate that the measurements of the site-related samples are probably artifacts.
3. Analytical result is a general class of compounds unsuitable for use in a quantitative risk assessment (e.g., total petroleum hydrocarbons); these analyses do not identify individual contaminants.
4. Contaminant is a nutrient or dietary requirement.

Table I.4-1 presents contaminants eliminated during the initial screening and the corresponding screening criteria. Table I.4-2 presents the results of the initial screening process for radionuclides and chemicals.

TABLE I.4-1
CONTAMINANTS ELIMINATED DURING INITIAL SCREENING

Radionuclides	**Chemicals** (Screening Criteria)[a]	
None	Alkalinity as $CaCO_3$ (3)	Potassium (4)
	Aluminum (1)	Silicon (1)
	Ammonia (3)	Sodium (4)
	Calcium (4)	Sulfate (2)
	Chloride (4)	Sulfide (2)
	Iron (4)	Total dissolved solids (3)
	Magnesium (2)	Total Kjeldahl nitrogen (3)
	Nitrate (2)	Total organic carbon (3)
	Oils and greases (3)	Total organic nitrogen (3)
	Phosphate (3)	Total organic halides (3)
	Phosphorous (3)	

[a] The four screening criteria are described in the first paragraph of Section I.4.3.

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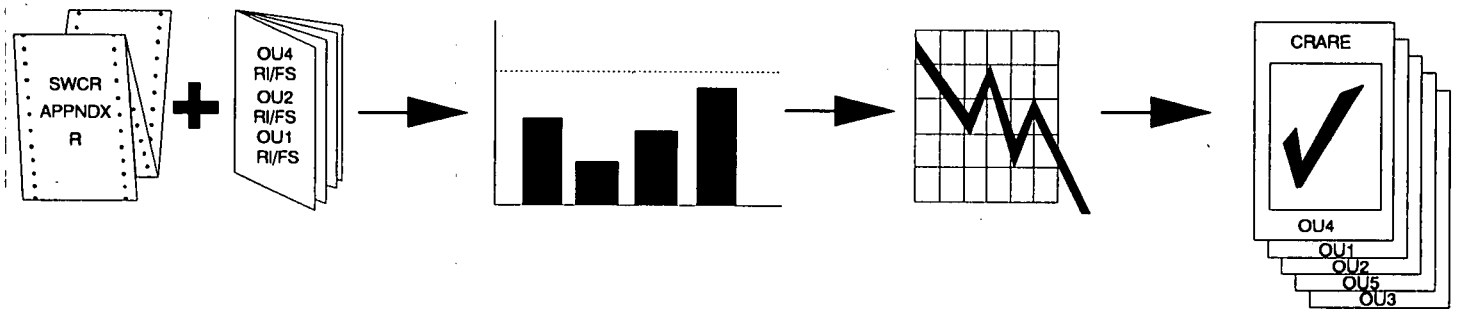

INITIAL CHEMICAL LISTING

FROM:

- SITE-WIDE LIST, SWCR APPENDIX R
- OU1 RI/FS
- OU2 RI/FS
- OU4 RI/FS

INITIAL SCREENING

REMOVE:

- NONTOXIC COMPOUNDS
- LAB ARTIFACTS
- ANALYTICAL RESULTS FOR GENERAL CLASSES OF COMPOUNDS
- NUTRIENTS

SECOND SCREENING

REMOVE:

- VOLATILES WITH VAPOR PRESSURE >10 mm HG

FINAL SCREENING

REMOVE:

- ORGANICS THAT DEGRADE IN SOIL BY 99.9% WITHIN 70 YEARS
- ORGANICS IN WATER THAT WILL BE REMOVED BY THE OU 5 GROUNDWATER PUMP AND TREAT SYSTEM

FIGURE I.4-1. COC SELECTION PROCESS

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TABLE I.4-2

POTENTIAL COCs IN EACH MEDIUM FOR EACH OPERABLE UNIT (AFTER INITIAL SCREENING)[a]

Compound	OU1	OU2	OU3	OU4	OU5
Chemical					
1,1-Dichloroethane			Surf, Sub		Sub, GW
1,1-Dichloroethane			Surf, Sub		GW
1,1,1-Trichloroethane			Surf, Sub		Sub, GW
1,1,2-Trichloroethane			Surf, Sub		GW
1,1,2,2-Tetrachloroethane			Surf, Sub		
1,2-Dichlorobenzene					GW
1,2-Dichloroethane			Sub		GW
1,2-Dichloroethylene			Surf, Sub		Sub, GW
1,4-Dioxane					Sub
2-Butanone			Surf, Sub	Berm, Surf	Sub, GW
2-Chlorophenol					Sub
2-Hexanone			Surf, Sub		Surf, Sub, GW
2-Methylnaphthalene		Surf	Surf, Sub		Sub
2-Nitrophenol					GW
2,3,4,6-Tetrachlorophenol					GW
2,4-Dimethylphenol					GW
2,6-Dinitrotoluene					GW
3-Nitroaniline					GW
4-Chloro-3-methylphenol			Sub		Sub
4-Methyl-2-pentanone			Surf, Sub		Surf, Sub, GW
4-Methylphenol					GW
4-Nitrophenol					Sub, GW
4,4-DDE		Surf			
4,6-Dinitro-2-methylphenol					GW
Acenaphthene		Surf	Surf, Sub	Surf	Sub
Acetone			Surf, Sub	Berm, Surf	Surf, Sub, GW
Anthracene			Surf, Sub	Surf	Sub
Antimony	Surf		Surf, Sub	Berm, Surf	Surf, Sub, GW
Aroclor-1221			Sub		
Aroclor-1248	Surf		Sub		
Aroclor-1254	Surf	Sed, Surf	Surf, Sub		Surf, Sub
Aroclor-1260	Surf	Surf	Surf, Sub		Sub
Arsenic	SW, Surf, Sed	Sed, Surf, SW, GW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Barium		Surf, SW	Surf, Sub	Berm, Surf	Sub, GW
Benzene			Surf, Sub		GW
Benzoic acid			Surf, Sub	Surf	Sub, GW

See footnotes at end of table.

TABLE I.4-2
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Benzo(a)anthracene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(a)pyrene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(b)fluoranthene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(g,h,i)perylene		Sed, Surf	Surf, Sub	Surf	Sub
Benzo(k)fluoranthene		Sed, Surf	Surf, Sub		Sub
Benzyl alcohol					GW
Beryllium	Sed, Surf	Sed, Surf, GW	Surf, Sub	Berm, Surf	Sub, GW
Beta-BHC			Surf, Sub		
Bis(2-ethylhexyl)phthalate		Sed, Surf, SW	Surf, Sub	Surf	Sub, GW
Boron	GW, Per				
Bromochloromethane					GW
Bromodichloromethane			Sub		Sub
Butylbenzyl phthalate			Sub		GW
Cadmium	Surf	Sed, Surf, SW		Berm, Surf	GW
Carbazole		Per, Sed, Surf			
Carbon disulfide			Surf, Sub		Sub, GW
Carbon tetrachloride			Sub		GW
Chlorobenzene			Surf, Sub		
Chloroethane			Sub		GW
Chloroform			Surf, Sub		Sub, GW
Chromium	Per, Surf	Sed, Surf		Berm	GW
Chrysene	Surf	Sed, Surf	Surf, Sub		Sub
Cobalt		Sed, Surf	Surf, Sub		Sub, GW
Copper	Per	Surf	Surf, Sub	Berm, Surf	Sub, GW
Cyanide		Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
Dibenzo(a,h)anthracene		Surf	Surf, Sub	Surf	Sub
Dibromochloromethane					Sub
Dieldrin		Surf			
Diethyl phthalate			Sub		Sub, GW
Di-n-butyl phthalate		Sed	Surf, Sub	Berm, Surf	Sub, GW
Di-n-octyl phthalate			Sub		
Endrin		Surf			
Ethylbenzene			Surf, Sub		Sub, GW
Fluoranthene		Sed	Surf, Sub	Surf	Sub
Fluorene			Surf, Sub		Sub
Heptachlorepoxide					GW
Heptachlorodibenzo-p-dioxin	Surf, GW	GW, Per			
Heptachlorodibenzofuran	Surf, GW				

See footnotes at end of table.

TABLE I.4-2
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Indeno(1,2,3-cd)pyrene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Isophorone					GW
Lead		Surf, Sed, SW, GW	Surf, Sub		Sub
Manganese	Per, GW, Surf	Sed, SW	Sub		GW
Mercury	Surf	GW	Surf, Sub		Sub, GW
Methylene chloride		Surf	Surf, Sub	Surf	Surf, Sub, GW
Molybdenum	Per, Surf	GW		Berm, Surf	Sub, GW
Naphthalene			Surf, Sub		Sub, GW
Nickel	Per, Surf	Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
N-Nitrosodiethylamine					GW
N-Nitroso-di-n-propylamine			Sub		
N-Nitrosodiphenylamine			Surf, Sub		GW
Octachlorodibenzo-p-dioxin	Surf, GW				
Pentachlorophenol	Surf				GW
Phenanthrene		Sed, Surf	Surf, Sub	Surf	Sub
Phenol			Surf, Sub	Berm, Surf	Sub, GW
Pyrene		Sed	Surf, Sub	Surf	Sub
Selenium		Surf, SW	Surf, Sub		Sub, GW
Silver	Surf, Per, SW				
Styrene			Surf, Sub		
Tetrachlorodibenzo-p-dioxin	Surf, GW	GW			
Tetrachlorodibenzofuran		Surf	Surf, Sub		Sub
Tetrachloroethene			Surf, Sub		Sub, GW
Thallium	Sed, Surf	Sed, Surf		Berm, Surf	GW
Thorium	Surf, GW, Per	Sed, Surf			
Toluene		Surf	Surf, Sub	Berm, Surf	Sub, GW
Total Xylenes			Surf, Sub	Berm	Sub, GW
Tributyl phosphate			Surf, Sub		GW
Trichloroethene			Surf, Sub		Sub, GW
Trichlorofluoromethane					GW
Uranium	Surf, GW, Per,	Sed, Surf, SW			
Vanadium	Surf	Surf		Berm, Surf	Sub, GW
Vinyl acetate					Sub, GW
Vinyl chloride			Sub		Sub, GW
Zinc	Surf, Per, SW	Surf	Surf, Sub	Berm, Surf	Sub, GW

See footnotes at end of table.

TABLE I.4-2
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Radionuclide					
Cs-137	Sed, SW, Surf	Surf, Sed	Surf, Sub		Surf, Sub
Np-237	Surf, Per	Surf, Sed, GW, SW	Sub		GW
Pa-231				Sub	
Pb-210				Berm	
Pu-238	Per, Surf, GW	Sed, Surf, SW	Surf, Sub		Surf
Pu-239	Sed, Surf	Surf, Sed, SW	Surf, Sub		Surf
Pu-240		Surf, Sed, SW	Surf, Sub		Surf
Ra-226		Sed, Surf, GW, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Ra-228	Per, Surf, GW	Sed, Surf, GW, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Rn-222[b]	A	A	A	A	A
Ru-106		Sed			
Sr-90	SW, Surf, Per	Sed, Surf	Surf, Sub	Surf	Surf, Sub, GW
Tc-99	Surf, SW, GW, Per	Surf, GW, Per, Sed	Surf, Sub	Surf	Surf, Sub, GW
Th-228	Surf, Per, GW, Sed	Sed, Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
Th-230	Surf, Per, GW	Sed, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub
Th-232	Surf, Per, Sed	Sed, Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
U-234	Surf, SW, Per, GW	Sed, GW, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
U-235	Surf, SW, Per, GW, Sed	Sed, Surf, GW, SW	Surf, Sub		Surf, Sub, GW
U-236		Sed, Surf, GW, SW	Surf, Sub		Surf, Sub, GW
U-238	Surf, SW, Per, Sed, GW	Sed, GW, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW

[a]Abbreviations used in this table:

A = Air
Berm = Berm fill
GW = Groundwater
Sed = Sediment
Per = Perched Groundwater
Sub = Subsurface soil
Surf = Surface soil
SW = Surface water

[b]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.

I.4.4 SECOND SCREENING OF COCs: VOLATILE LOSSES

This section details the second COC screening procedures employed for each of the five operable units. The CRARE time frames for all scenarios begin after completion of all remedial actions at the FEMP. The time period needed to complete the remedial actions is assumed to be 70 years. This value is derived from the assumption in the Operable Unit 5 RI report (DOE 1994c) that the ongoing remediation of the South Groundwater Contamination Plume will continue for 70 years. The remediation of on-site groundwater contamination will probably require a similar time period. Therefore, volatile chemicals for all operable units were eliminated because they would be lost to the atmosphere prior to the 70- or 1000-year postremediation time frames. Volatile chemicals are defined as those chemicals with a vapor pressure greater than 10 millimeters (0.4 inches) of mercury at 20°C (68°F). This concept is based on the *Air/Superfund National Technical Guidance Series, Volume III* (EPA 1985a). Additionally, remediation activities implemented before the time frame considered in the CRARE would be expected to disturb, expose, and mix many of the areas with VOC contamination and thereby hasten the evaporation of these contaminants.

Each operable unit is at a different stage of the remediation process and therefore requires a different degree of contaminant screening. Table I.4-3 presents the remaining COCs following the secondary screening as applied to each of the operable units.

I.4.4.1 Operable Units 1, 2 and 4

The data for Operable Units 1, 2 and 4 (Table I.4-3) have been analyzed in recent RI and FS reports, and are not expected to change significantly.

I.4.4.2 Operable Unit 3

At this time, these contaminants (Table I.4-3) are considered potential COCs. Further analysis and screening, including frequency-of-detection and concentration-toxicity analysis, shall be employed to further eliminate contaminants when the CRARE for Operable Unit 3 is prepared.

TABLE I.4-3

POTENTIAL COCs IN EACH MEDIUM FOR EACH OPERABLE UNIT (AFTER SECOND SCREENING)[a]

Compound	OU1	OU2	OU3	OU4	OU5
Chemical					
1,1,2,2-Tetrachloroethane			Surf, Sub		
2-Hexanone			Surf, Sub		Surf, Sub, GW
2-Methylnaphthalene		Surf	Surf, Sub		Sub
3-Nitroaniline					GW
4-Chloro-3-methylphenol			Sub		Sub
4-Methyl-2-pentanone			Surf, Sub		Surf, Sub, GW
4,4-DDE		Surf			
Acenaphthene		Surf	Surf, Sub	Surf	Sub
Anthracene			Surf, Sub	Surf	Sub
Antimony	Surf		Surf, Sub	Berm, Surf	Surf, Sub, GW
Aroclor-1221			Sub		
Aroclor-1248	Surf		Sub		
Aroclor-1254	Surf	Sed, Surf	Surf, Sub		Surf, Sub
Aroclor-1260	Surf	Surf	Surf, Sub		Sub
Arsenic	SW, Surf, Sed	Sed, Surf, SW, GW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Barium		Surf, SW	Surf, Sub	Berm, Surf	Sub, GW
Benzoic acid			Surf, Sub	Surf	Sub, GW
Benzo(a)anthracene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(a)pyrene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(b)fluoranthene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Benzo(g,h,i)perylene		Sed, Surf	Surf, Sub	Surf	Sub
Benzo(k)fluoranthene		Sed, Surf	Surf, Sub		Sub
Benzyl alcohol					GW
Beryllium	Sed, Surf	Sed, Surf, GW	Surf, Sub	Berm, Surf	Sub, GW
Beta-BHC			Surf, Sub		
Bis(2-ethylhexyl)phthalate		Sed, Surf, SW	Surf, Sub	Surf	Sub, GW
Boron	GW, Per				
Butylbenzyl phthalate			Sub		GW
Cadmium	Surf	Sed, Surf, SW		Berm, Surf	GW
Carbazole		Per, Sed, Surf			
Chlorobenzene			Surf, Sub		
Chromium	Per, Surf	Sed, Surf		Berm	GW
Chrysene	Surf	Sed, Surf	Surf, Sub		Sub
Cobalt		Sed, Surf	Surf, Sub		Sub, GW
Copper	Per	Surf	Surf, Sub	Berm, Surf	Sub, GW
Cyanide		Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
Dibenzo(a,h)anthracene		Surf	Surf, Sub	Surf	Sub
Dieldrin		Surf			
Diethyl phthalate			Sub		Sub, GW
Di-n-butyl phthalate		Sed	Surf, Sub	Berm, Surf	Sub, GW
Di-n-octyl phthalate			Sub		
Endrin		Surf			

See footnotes at end of table

TABLE I.4-3
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Ethylbenzene			Surf, Sub		Sub, GW
Fluoranthene		Sed	Surf, Sub	Surf	Sub
Fluorene			Surf, Sub		Sub
Heptachlorodibenzofuran	Surf, GW				
Heptachlorodibenzo-p-dioxin	Surf, GW	GW, Per			
Indeno(1,2,3-cd)pyrene	Surf	Sed, Surf	Surf, Sub	Surf	Sub
Lead		Surf, Sed, SW, GW	Surf, Sub		Sub
Manganese	Per, GW, Surf	Sed, SW	Sub		GW
Mercury	Surf	GW	Surf, Sub		Sub, GW
Molybdenum	Per, Surf	GW		Berm, Surf	Sub, GW
Naphthalene			Surf, Sub		Sub, GW
Nickel	Per, Surf	Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
N-Nitroso-di-n-propylamine			Sub		
N-Nitrosodiphenylamine			Surf, Sub		GW
Octachlorodibenzo-p-dioxin	Surf, GW				
Pentachlorophenol	Surf				GW
Phenanthrene		Sed, Surf	Surf, Sub	Surf	Sub
Phenol			Surf, Sub	Berm, Surf	Sub, GW
Pyrene		Sed	Surf, Sub	Surf	Sub
Selenium		Surf, SW	Surf, Sub		Sub, GW
Silver	Surf, Per, SW				
Styrene			Surf, Sub		
Tetrachlorodibenzofuran		Surf	Surf, Sub		Sub
Tetrachlorodibenzo-p-dioxin	Surf, GW	GW			
Thallium	Sed, Surf	Sed, Surf		Berm, Surf	GW
Thorium	Surf, GW, Per	Sed, Surf			
Total Xylenes			Surf, Sub	Berm	Sub, GW
Tributyl phosphate			Surf, Sub		GW
Uranium	Surf, GW, Per, SW	Sed, Surf, SW			
Vanadium	Surf	Surf		Berm, Surf	Sub, GW
Zinc	Surf, Per, SW	Surf	Surf, Sub	Berm, Surf	Sub, GW
Radionuclide					
Cs-137	Sed, SW, Surf	Surf, Sed	Surf, Sub		Surf, Sub
Np-237	Surf, Per	Surf, Sed, GW, SW	Sub		GW
Pa-231				Sub	
Pb-210				Berm	
Pu-238	Per, Surf, GW	Sed, Surf, SW	Surf, Sub		Surf
Pu-239	Sed, Surf	Surf, Sed, SW	Surf, Sub		Surf
Pu-240		Surf, Sed, SW	Surf, Sub		Surf
Ra-226		Sed, Surf, GW, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
Ra-228	Per, Surf, GW	Sed, Surf, GW, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW

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See footnotes at end of table

TABLE I.4-3
(Continued)

Compound	OU1	OU2	OU3	OU4	OU5
Rn-222[b]	A	A	A	A	A
Ru-106		Sed			
Sr-90	SW, Surf, Per	Sed, Surf	Surf, Sub	Surf	Surf, Sub, GW
Tc-99	Surf, SW, GW, Per	Surf, GW, Per, Sed	Surf, Sub	Surf	Surf, Sub, GW
Th-228	Surf, Per, GW, Sed	Sed, Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
Th-230	Surf, Per, GW	Sed, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub
Th-232	Surf, Per, Sed	Sed, Surf	Surf, Sub	Berm, Surf	Surf, Sub, GW
U-234	Surf, SW, Per, GW	Sed, GW, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW
U-235	Surf, SW, Per, Sed, GW	Sed, Surf, GW, SW	Surf, Sub		Surf, Sub, GW
U-236		Sed, Surf, GW, SW	Surf, Sub		Surf, Sub, GW
U-238	Surf, SW, Per, Sed, GW	Sed, GW, Surf, SW	Surf, Sub	Berm, Surf	Surf, Sub, GW

[a]Abbreviations used in this table:

A = Air
Berm = Berm fill
GW = Groundwater
Per = Perched Groundwater
Sed = Sediment
Sub = Subsurface soil
Surf = Surface soil
SW = Surface water

[b]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.

I.4.4.3 Operable Unit 5

Operable Unit 5 is defined as those environmental media at the site that are not being addressed by the other operable units. According to the implementation schedule, the Operable Unit 5 remedial actions would be completed after finishing the actions for the other operable units. All COCs from the other operable units are assumed to be present in some residual concentration following remediation. Contaminants having passed the initial and second screenings were combined to produce the Operable Unit 5 COC list (Table I.4-3). Both validated and invalidated data were used to compile this list. Further fate and transport modeling efforts will refine the Operable Unit 5 COCs.

I.4.5 FINAL SCREENING OF COCs

To reflect the forward-looking nature of the CRARE, the final screening addressed elimination of organic chemicals that would degrade or be removed from the site prior to the time period considered in the CRARE. The half-lives of organic constituents remaining in the soil were examined, and those constituents were screened out for which the original concentration would degrade by three orders of magnitude (99.9 percent) or greater during the 70-year remediation period. This standard also indicates that the screened-out constituents will degrade by five orders of magnitude (99.999 percent) or greater after the initial 30 years of the CRARE scenarios. For this final screening the concentration decay rate of organic constituents in soil, over time, was calculated using the formula below:

$$C/C_o = e^{-(\ln 2/T)t} \qquad (1)$$

where

C = the concentration at time t,
C_o = the initial concentration (UCL),
T = the half-life in days, and
t = time in days.

Except were otherwise noted, half-life values for constituents in soil were obtained from the *Handbook of Environmental Degradation Rates* (Howard et al. 1991), which was the result of work performed for the EPA. The highest half-life values were used. Those constituents were eliminated that showed a reduction in concentration of 99.9 percent or greater at or before 70 years, as discussed above. For example, using the half-life in soil from Howard for benzo(a)pyrene:

$$T = 530 \text{ days}$$

where

t = 25,550 days (70 years) during remediation, and

C/C_o = 3.08×10^{-15} or a 100 percent reduction.

Therefore, benzo(a)pyrene was eliminated.

In addition, organic constituents present in the groundwater were assumed to be removed from the site through a groundwater pump and treat operation. Thus, organics that were identified as COCs in groundwater only were eliminated from further consideration in the CRARE. Organic constituents which were COCs in media other than groundwater were not eliminated solely based on the pump and treat operation. Table I.4-4 lists the organic chemicals that were addressed in the final screening process. The table presents the half-life in soil of each compound and identifies those retained as COCs.

It should be noted that this screening assumption will be reevaluated for each operable unit as additional information concerning COCs becomes available. Each operable unit will propose specific methods for remediation of these organic contaminants.

The impact of these screening assumptions on the masses of the organic constituents in the Operable Unit 5 soils can also be evaluated. Table I.4-5 lists the masses that are estimated to remain after degradation for the five screened-out compounds with the longest half-lives in Table I.4-4. The initial masses in the soil are calculated in the Operable Unit 5 RI (Table 5-13). Pyrene has the highest initial mass of the 50 organic compounds listed in this table. The 70-year period represents the duration of remedial activities at the site. The 100-year period includes these 70 years plus the first 30 years of the CRARE scenarios. The masses of the screened-out chemicals that are not listed in Table I.4-5 would all degrade to less then 1×10^{-8} kg.

Table I.4-6 shows the contaminants retained after implementing the final screening process.

TABLE I.4-4

FINAL SCREENING OF ORGANIC CHEMICALS[a]

Organic Chemical	Half-life (days)	Retained or Screened Out
2-Hexanone	14[b]	Screened out
2-Methylnaphthalene	No Data	Retained
3-Nitroaniline	No Data[c]	Screened out
4-Chloro-3-methylphenol	14[d]	Screened out
4-Methyl-2-pentanone	7	Screened out
4,4-DDE	5694	Retained
Acenaphthene	102	Screened out
Anthracene	460	Screened out
Aroclor-1221	No Data	Retained
Aroclor-1248	No Data	Retained
Aroclor-1254	No Data	Retained
Aroclor-1260	No Data	Retained
Benzoic acid	7	Screened out
Benzo(a)anthracene	680	Screened out
Benzo(a)pyrene	530	Screened out
Benzo(b)fluoranthene	610	Screened out
Benzo(g,h,i)perylene	650	Screened out
Benzo(k)fluoranthene	2140	Screened out
Benzyl alcohol	No Data[c]	Screened out
Beta-BHC	124	Screened out
Bis (2-ethylthexyl) phthalate	23	Screened out
Butylbenzyl phthalate	7	Screened out
Carbazole	No Data	Retained
Chlorobenzene	150	Screened out
Chrysene	1000	Screened out
Dibenzo(a,h)anthracene	940	Screened out
Dieldrin	1095	Screened out
Diethyl phthalate	56	Screened out
Di-n-butyl phthalate	23	Screened out
Di-n-octyl phthalate	28	Screened out
Endrin	No Data	Retained
Ethylbenzene	10	Screened out
Fluoranthene	440	Screened out
Fluorene	60	Screened out
Heptachlorodibenzo-p-dioxin	No Data	Retained
Heptachlorodibenzofuran	No Data	Retained
Indeno(1,2,3-cd)pyrene	730	Screened out

See footnotes at end of table.

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TABLE I.4-4
(Continued)

Organic Chemical	Half-life (days)	Retained or Screened Out
Naphthalene	48	Screened out
N-Nitroso-di-n-propylamine	180	Screened out
N-Nitrosodiphenylamine	34	Screened out
Octachlorodibenzo-p-dioxin	No Data	Retained
Pentachlorophenol	178	Screened out
Phenanthrene	200	Screened out
Phenol	10	Screened out
Pyrene	1900	Screened out
Styrene	28	Screened out
Tetrachlorodibenzofuran	No Data	Retained
Tetrachlorodibenzo-p-dioxin	No Data	Retained
Total xylenes	28	Screened out
Tributyl phosphate	140[e]	Screened out

[a]The soil degradation rates for PAHs were obtained from the Handbook of Environmental Degradation Rates by P.H. Howard et al. (1991). This monograph was produced for the EPA to specifically develop Chemical Fate Rate Constants for the Superfund Amendments and Reauthorization Act (SARA) Section 313 chemicals and Superfund Health Evaluation Manual Chemicals. Therefore, DOE assumes that these half-lifes are correct since they are promulgated by EPA. The soil degradation rates were presented in the monograph as a range of soil half-lifes. To be health-conservative, the maximum soil half-lifes were used in the CRARE for purposes of calculating percent soil concentrations remaining after 70 years.

Recently the ATSDR (October 1993) released an updated draft Toxicological Profile for the PAHs: "Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of PAHs is available. Where adequate information is not available, ATSDR, in conjunction with the NTP (National Toxicology Program), is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of PAHs." The adequacy of the database on the environmental fate of PAHs was specifically evaluated "by a joint team of scientists form ATSDR, NTP and EPA." The findings of this team included the following: "The environmental fate of PAHs is well characterized." "PAHs are transported in and partitioned to the air, water, and soil. Transformation and degradation processes of PAHs in the air, water, and soil have been well studied." "Microbial metabolism is the major process for degradation of PAHs in soil environments." "No further studies are needed."

[b]Half-life in soil assumed to be twice the value for 2-Butanone.

[c]Compounds removed from groundwater during pump and treat operation, not considered in CRARE.

[d]Half-life in soil assumed to be twice the value for 2-Methylphenol.

[e]Half-life in soil assumed to be 10 times its half-life in surface water/sediment (Montgomery 1991).

TABLE I.4-5

EFFECT OF DEGRADATION ON SCREENED-OUT CHEMICALS

Organic Chemical	Half-life (days)	Initial Mass in Soil (kg)	Mass after 70 years (kg)	Mass after 100 years (kg)
Benzo(k)fluoranthene	2140	1.10×10^{3}	2.80×10^{-1}	8.08×10^{-3}
Pyrene	1900	2.69×10^{4}	2.41×10^{0}	4.44×10^{-2}
Dieldrin	1095	5.32×10^{0}	5.04×10^{-7}	4.92×10^{-10}
Chrysene	1000	3.94×10^{3}	8.03×10^{-5}	4.06×10^{-8}
Benzo(a)anthracene	680	3.44×10^{3}	1.68×10^{-8}	2.40×10^{-13}

TABLE I.4-6

COCs RETAINED AFTER FINAL SCREENING FOR ALL OPERABLE UNITS

Radionuclide	Chemical	
Cs-137	2-Methylnaphthalene	Cyanide
Np-237	4,4-DDE	Endrin
Pa-231	Antimony	Lead
Pb-210	Aroclor-1221	Manganese
Pu-238	Aroclor-1248	Mercury
Pu-239	Aroclor-1254	Molybdenum
Pu-240	Aroclor-1260	Nickel
Ra-226	Arsenic	Selenium
Ra-228	Barium	Silver
Rn-222	Beryllium	Tetrachlorodibenzo-p-dioxin[a]
Ru-106	Boron	Thallium
Sr-90	Cadmium	Thorium
Tc-99	Carbazole	Uranium
Th-228	Chromium	Vanadium
Th-230	Cobalt	Zinc
Th-232	Copper	
U-234		
U-235		
U-236		
U-238		

[a]All isomers of dioxins and furans were evaluated using toxicity equivalency factors (TEFs) to 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin.

I.5.0 EXPOSURE SCENARIOS

This section discusses the steps taken to identify, screen, and develop the CRARE exposure scenarios. The exposure scenarios were defined by assuming implementation of the LRAs described in the SWCR for Operable Units 3 and 5 and the PRAs presented in the Operable Unit 1, 2, and 4 RI/FS reports. This approach is consistent with the Amended Consent Agreement. A quantitative risk analysis is presented in Section I.8.0.

The exposure scenarios developed for this CRARE describe three sets of land use conditions:

1. The Current Land Use scenario assumes government ownership, maintenance, and access control for 70 years after completion of all FEMP remedial actions.

2. The Future Land Use With Federal Ownership scenario describes the site up to 1000 years after remedial actions are complete, and assumes continued government ownership and land use control, but no other access control.

3. The Future Land Use Without Federal Ownership scenario also describes the site up to 1000 years after remedial actions are complete, but assumes occupation by a resident farm.

These scenarios provide a basis for evaluating the potential exposures in the environment following the completion of remedial actions. However, the accuracy of the scenarios depends on the ability to predict site conditions well into the future. It should be recognized that projected land uses, as well as a description of the FEMP up to 1000 years hence, are speculative.

In general, each exposure scenario is made up of the same components: a source of contaminants, mechanisms that facilitate the transport of contaminants from the source through various environmental media, receptors in the local environment, and a route or mechanism of exposure for those receptors. Based on these components, three steps were involved in developing the exposure scenarios:

1. Characterization of the exposure setting

2. Identification of potential exposure pathways

3. Selection of site-specific exposure pathways to be quantitatively evaluated.

In the development of the exposure scenarios, the environmental setting of the FEMP years after the completion of remediation was evaluated. The characteristics of the FEMP setting influenced the types of transport mechanisms and receptor activities selected.

I.5.1 CHARACTERIZATION OF EXPOSURE SETTING

The characterization of the exposure setting relied on the definition of the operable units, the actions proposed in the remedial alternatives, and the existing characterization information from the RIs to establish the nature of changes caused by each remedial action to each operable unit. The source areas of contamination considered for each operable unit were the original areas plus new areas associated with the on-property disposal facilities. Material moved off-property during remediation was not considered in the compilation of risks.

I.5.1.1 Physical Environment

This section describes the future physical environment of the site for up to 1000 years after remediation as it relates to the individual release mechanisms and pathways to be screened. This information was developed from the Operable Unit 1, 2, and 4 RI/FS reports and the SWCR.

Surface Topography

The topography of the FEMP may be substantially altered after remediation. Man-made aboveground structures would be removed, and areas would be excavated, graded, and in some cases capped or covered and vegetated. On-property disposal facilities may be erected. Additionally, surface drainage ponds would be maintained during and possibly immediately after remediation, and then left unattended or backfilled for the remainder of the 1000-year evaluation period. In general, the overall FEMP in the future would have fewer man-made obstructions and would eventually revert to woods and perhaps a mature forest.

Surface Hydrology

Surface water drainage would change on the FEMP due to the removal of man-made structures and nonporous areas. The addition of new, impervious areas have the potential to create new channels of surface water runoff. Wetlands have been identified on the FEMP and may continue to emerge, depending on climate and perched-water conditions. Paddys Run would be a potential

source of exposure, as would newly formed and existing wetlands, ponds, and channel creeks. The storm water treatment system is a significant feature for the Current Land Use scenario.

Demographics

Regardless of which scenario is implemented, the local surrounding land use is expected to remain primarily agricultural. New recreational areas, urban population centers, and commercial or industrial areas are not envisioned. For the purposes of this analysis, the same potentially exposed populations (see Section I.5.1.3) were assumed to exist in the future scenarios.

Historical Significance

Known sites of archaeological significance within the boundaries of the FEMP, if any, will be identified during the on-going RI/FS process. The sites will be managed appropriately, pursuant to the National Historic Preservation Act (36 CFR 800, Section 106).

Geology and Hydrogeology

The geological and hydrological characteristics of the FEMP and its surrounding areas have been numerically modeled to reflect the proposed FEMP remediation plans. The assumptions that support this modeling appear in Section I.2.1. Descriptions of site conditions and the development of the computer models are in the SWCR. Postremediation groundwater conditions are summarized in Section I.6.1.6 of this CRARE.

Ecological Setting

In the Current Land Use scenario, 70 years after remediation, vegetation planted at the operable unit residual footprints will be approaching successional maturity. The deciduous forest vegetation would be invading the site. Wildlife would progress from grassland species to an increasing abundance of deciduous forest species. In the northern region of the FEMP, the wetland is anticipated to expand further with the increased runoff from the on-property disposal facilities. This loss of runoff area and the subsequent filling of the drainage and sedimentation ponds would eventually lead to the emerging wetland becoming a recipient drainage area.

In the Future Land Use scenarios, up to 1000 years after remediation, many types of forests or other ecological settings may occur. The deciduous forest invasions are assumed to have grown to

a mature forest. In some areas, roots from trees may invade the capped/covered areas and the former footprints of the operable units. The emerging wetlands may be fully developed, fluctuating with natural changes in the shallow water table. Contamination would potentially be available to vegetation and terrestrial and aquatic species.

I.5.1.2 Land Use

Because of the uncertainty associated with future sociopolitical activities, three potential exposure scenarios have been evaluated. The Current Land Use scenario assumes that the government would control the FEMP for up to 70 years after site remediation. Under this assumption, access controls at the FEMP would remain in effect. At a minimum, a security fence would surround the entire FEMP property and would be regularly patrolled by a security force. Access controls are assumed to be effective in restricting intruders' access and short-term forays. Two Future Land Use scenarios (with and without federal ownership) have been evaluated for a period of up to 1000 years after remediation without access controls.

I.5.1.3 Potentially Exposed Populations

This section evaluates the relevance to this CRARE of human receptors on or in the vicinity of the FEMP who have been presented in the Operable Unit 1, 2 and 4 RI/FS reports (Table I.5-1). These populations have been examined to determine if they have the potential for significant exposure to contaminants under future site conditions. Those populations determined to present a reasonable possibility of significant exposure based on postremediation site conditions have been retained for examination in this CRARE. The following paragraphs provide details on the nature of the receptors and their respective pertinent exposure pathways.

I.5.1.3.1 Screening of Receptors and Exposure Pathways

Groundskeeper. A worker is assumed to be present on the property conducting groundskeeping and maintenance throughout the FEMP (not just for Operable Units 1 and 2). This is consistent with future postremediation site conditions, and therefore the groundskeeper has been evaluated in this CRARE. No groundwater would be used by this receptor. Exposure pathways include inhalation of fugitive dusts, organics, and gases, dermal contact with and incidental ingestion of site soil, and external radiation exposure while on site.

TABLE I.5-1

RECEPTORS EVALUATED FOR THE OU1&2 CRARE

Receptor	Retained	Eliminated
Groundskeeper	X	
Trespassing Child	X	
Expanded Trespasser	X	
Off-Property Farm Residents:		
Adult	X	
Child	X	
On-Property Farm Residents:		
Adult (Ingests Great Miami Aquifer Water)	X	
Adult (Ingests Perched Groundwater)	X	
Adult (Central Tendency)		X
Child	X	
Homebuilder		X
Homebuilder/Resident		X
River Water Drinker		X
Visitor		X
Consumer of Animal Products		X

Trespassing Child. This hypothetical receptor addresses the potential exposures incurred by a child (age 7 through 18) who lives off-property but regularly trespasses onto the FEMP site. Relevant exposure pathways include inhalation of fugitive dusts, organics, and gases, dermal contact with and incidental ingestion of site soil, incidental ingestion of contaminated surface water while wading, and external radiation exposure while on site. This receptor has been included in this CRARE.

Expanded Trespasser. The expanded trespasser is a composite adult/child who illegally uses the site for recreational purposes. This hypothetical individual is assumed to visit the site despite continued government ownership. Exposure pathways include inhalation of fugitive dusts, volatile

organics, and gases, dermal contact with and incidental ingestion of site soil, incidental ingestion of surface water in Paddys Run, and external radiation exposure while on site. For these reasons, this receptor has been evaluated in this CRARE. No specific location was assigned as the expanded trespasser may wander over the entire FEMP, with the exception of the caps and vaults.

For the purposes of establishing a cleanup level for the Future Land Use With Federal Ownership scenario, an on-property receptor was employed assuming a trespassing exposure scenario that includes both adult and child age groups. The frequency of exposure was expanded to account for the lack of access controls. This expanded trespassing scenario was employed because it represents an upper bound estimate of the exposures a receptor could reasonably be expected to receive. This assumes the federal government would continue to own the site, thus precluding site development for residential, farm, industrial/commercial, or recreational use (e.g., ball fields, jogging trails, and biking trails). This assumption will be re-evaluated in the Operable Unit 5 CRARE.

It was assumed that Paddys Run fish are not considered a pathway for chemical or radiological intake by this receptor because of the composition of the fish populations. Paddys Run is a small, intermittent tributary of the Great Miami River running north to south along the western edge of the FEMP. Surveys of the Paddys Run fish population concluded that the stream does not support any sport fish in most of the stream sections. Surveys completed by Facemire et al. (1990), Miller et al. (1990), and those completed for the RI/FSs in general, concluded the majority of the stream population was composed of members of the darter, minnow, and sunfish families. In Paddys Run, these fish are too small or undesirable for human consumption. Some sport fish can be found in Paddys Run at the confluence of the Great Miami River. However, because of fish movement and feeding patterns, these fish are considered only in conjunction with the Great Miami River. Crayfish, which are present in Paddys Run, are primarily consumed by raccoons and as such are addressed in the Ecological Risk Assessment for the Operable Unit 5 RI.

<u>On-Property Resident Farm Adult (Ingests Great Miami Aquifer Water)</u>. Consistent with the RME concept and to ensure the estimated risk values protect human health and the environment, it was assumed that the remediated FEMP site could revert to residential and agricultural uses in

the future and that an adult farmer could reside on the site after it is remediated. Potential exposures to this receptor may result from external radiation residual contamination from remediated site footprints, and/or waste leaking from vaults.

Exposure pathways examined for this receptor include growing food, tending livestock, and performing general farm work. These activities may result in direct exposure to residual site contamination, consumption of contaminated produce, dairy products, and meat, ingestion of contaminated water from the Great Miami Aquifer, dermal absorption through contact with residually contaminated soil, inhalation of gases, vapors, and dust, and incidental ingestion of soil. This receptor has been evaluated in this CRARE; the selected RME location is presented in Sections I.6.1.6.2 and I.6.2.10.

On-Property Resident Farm Adult (Ingests Perched Groundwater). This receptor addresses the potential additional exposure incurred by the on-property resident farm adult if the drinking water source is the perched groundwater. This receptor has been evaluated in this CRARE; the selected RME location is presented in Section I.6.1.6.2.

On-Property Resident Farm Adult (Central Tendency). This receptor addresses the potential exposure incurred by the on-property resident farm adult using slightly less conservative, central-tendency exposure parameters. Exposure pathways examined include growing food, tending livestock, and performing general farm work. These activities may result in direct exposure to residual site contamination, consumption of contaminated produce, dairy products, and meat, ingestion of contaminated water from the Great Miami Aquifer, dermal absorption through contact with residually contaminated soil, inhalation of gases, vapors, and dust, and incidental ingestion of soil.

The inclusion of a central-tendency analysis will not significantly reduce the overall health risks for the adult farm receptor. An examination of the impact of including central-tendency parameters in the calculation of on-property farm adult risks has indicated that a reduction of approximately a factor of 3 can be achieved. This reduction is mainly due to the slight reduction in exposure duration (350 versus 275 days) and minor reductions in the individual pathway contact rate.

The CRAREs evaluate the potential exposure of hypothetical receptors to postremediation concentrations of on-property COCs. Therefore, the temporal setting of the CRAREs is different from the RI and FS risk assessments, both of which included central-tendency analyses. Because of the postremediation setting of the CRAREs, all exposure parameters are estimated. The uncertainty inherent in all CRARE exposure estimates makes the additional uncertainty of central tendency inappropriate. In addition, recent guidance from EPA Region V has requested more conservative exposure parameters than those previously used to describe the CRARE RME receptors. A central-tendency analysis would result in the use of less conservative exposure parameters, and would thus not comply with the EPA guidance. On the basis of this evaluation, central tendency was rejected.

On-Property Resident Farm Child. Young children (age 1 through 6) living on the property would form a subpopulation of concern, because they may be more sensitive to a given exposure than are adults. For these reasons, this receptor has been evaluated in this CRARE. A young child residing on the remediated FEMP could be exposed directly to residual site contaminants remaining in soils, and could inhale gases, vapors, and dust. In the CRARE risk calculations, this hypothetical child of the on-property resident farm adult is assumed to drink Great Miami Aquifer water from an on-property well and to consume vegetables, fruit, meat, and dairy products produced on the property. The selected RME location of this receptor is presented in Sections I.6.1.6.2 and I.6.2.10.

Off-Property Resident Farm Adult. The inclusion of a farmer, assumed to live immediately adjacent to the remediated FEMP property boundary, was determined to be highly likely based on current conditions and has therefore been included in this CRARE. The major concern for this receptor is the exposure received from regular use of water from the Great Miami Aquifer (drinking and agricultural uses). This farmer could also be exposed to COCs from remote on-property residual sources, and/or other contaminants carried by the wind as gases, vapors, and dust. However, he would not be exposed to on-property soil from dermal contact or receive external radiation from on-site soil. The selected RME location of this receptor is presented in Sections I.6.1.6.2 and I.6.2.10.

Off-Property Resident Farm Child. This hypothetical child (age 1 through 6) of the off-property resident farm adult is assumed to have the same diet as the parent. This child could also be exposed to COCs from remote on-property residual sources, and/or other contaminants carried by the wind as gases, vapors, and dust. For these reasons, this receptor has been evaluated in this CRARE; the selected RME location is presented in Sections I.6.1.6.2 and I.6.2.10

Homebuilder and Homebuilder/Resident. These receptors were eliminated from further evaluation in this CRARE, based on the proposed postremediation site conditions. All residual materials above cleanup levels will be covered by caps or covers which would hinder and obstruct construction activities. Materials readily available for exposure to these receptors will be at or below the cleanup levels. Due to the greatly reduced exposure duration and pathways, a homebuilders's exposure from these uncapped areas would be below the exposure calculated for the RME on-property resident farm adult.

Based on guidance from Region V, a homebuilder would be expected to have a typical exposure of 500 hours during homebuilding activities. Half of the exposure would be inside the structure (wiring, plumbing, flooring, drywall installation). The acute exposure experienced by the homebuilder is far less than that of the farmer. Acute exposures are not evaluated in the CRAREs.

Great Miami River User. This scenario was designed to evaluate the exposures incurred during the activities of a receptor who frequently uses the Great Miami River for recreational purposes. This receptor has been evaluated in the Operable Unit 1 and 2 RI/FS reports, which show that both noncarcinogenic hazards and carcinogenic risks are insignificant compared to exposures calculated for the expanded trespasser. Therefore, the Great Miami River user is not evaluated in this CRARE.

Visitor. This scenario is intended to evaluate exposures incurred by the activities of a regular visitor to the FEMP who is not covered by a health and safety plan or radiation protection program. An example of this receptor would be a delivery person making regular deliveries to a given building on the site. The major concern for this receptor is the exposure to contaminants transported by the wind in the form of gases, vapors, and dusts generated during remedial

activities. This receptor is not further developed in the CRARE, since the CRARE evaluates postremediation hazards and risks. After remediation, a visitor would not be an applicable receptor.

Consumer of Animal Products. This scenario considers the hazards and risks associated with the use of animal products produced by cattle grazing on the FEMP site. This exposure has been evaluated and quantified for the on- and off-property resident farm receptors in this CRARE, and has therefore been eliminated as a separate receptor.

I.5.1.3.2 Selected Receptors and Scenarios

In this CRARE, four hypothetical receptors were selected for the Current Land Use scenario, which assumes government ownership for 70 years after remediation. Each receptor represents a unique population and exposure scenario. As a whole, they cover a wide range of exposure scenarios for potentially impacted human receptors. The four receptors are:

1. Groundskeeper
2. Trespassing child
3. Off-property resident farm adult
4. Off-property resident farm child

For the Future Land Use With Federal Ownership scenario, which assumes government ownership for up to 1000 years after the remediation, four receptors were selected:

1. Trespassing child
2. Expanded Trespasser
3. Off-property resident farm adult
4. Off-property resident farm child

For the Future Land Use Without Federal Ownership scenario, which assumes private ownership for up to 1000 years after the remediation, five receptors were selected:

1. On-property resident farm adult (who ingests perched groundwater)
2. On-property resident farm adult (who ingests Great Miami Aquifer water)
3. On-property resident farm child
4. Off-property resident farm adult
5. Off-property resident farm child

I.5.1.3.3 Locations of Reasonable Maximum Exposure

Receptor locations were selected based on the graphical representation of modeled air, soil, and water COC concentrations from remediated conditions. In keeping with the philosophy of evaluating the RME individual, the locations of highest on- and off-property exposures were assessed.

The RME locations were determined by first locating areas on and off the FEMP property which would receive elevated levels of COCs. The estimated COC concentrations in the environment were developed using computer modeling, as described in detail in Section I.6.0. Time-weighted exposure concentrations at these areas, along with exposure parameters, were then considered to define exposure pathways and to quantify the potential COC intake by the receptor.

The resulting intakes by potential receptors at various locations were then compared, and the location producing the highest intake was designated as the RME location. In the case of multiple pathways and contaminants, the resulting risks and hazard values were considered in the selection of the RME location.

Due to the multiple sources of COCs, the different patterns of COC fate and transport in the environment, and the variety of COC release mechanisms at the FEMP, a complex matrix of interdependent effects was found to exist among COCs, exposure pathways, and the resulting exposure concentrations. Consequently, the selection of the site-wide RME locations required careful comparison of dispersion concentrations and estimated risk values.

I.5.2 DETAILED CONCEPTUAL EXPOSURE MODEL

A detailed conceptual exposure model is presented here which builds upon the CRARE Site-Wide Conceptual Model presented in Section I.1.6. This model has been developed to provide the basis for identifying and evaluating the potential risk to human health after the FEMP is remediated. The key objective of the model is to facilitate the analysis of exposure routes and receptors, focus on those pathways and sources that drive the potential impacts on human health risk, and screen out other exposure pathways that are likely to pose minor risks.

The model provides a consistent and comprehensive evaluation of the risk to human health by creating a framework for identifying the mechanisms by which human health may be affected by the remediated site. The elements necessary to construct a complete exposure pathway, and thus develop the conceptual model, are as follows:

- Sources of residual contaminants
- Release mechanisms
- Transport pathways
- Exposure pathways
- Receptors

The model traces the exposure pathways from the sources through the release mechanisms and exposure routes to the affected receptors. The model also indicates which exposure routes are carried through the quantitative risk assessment for each receptor under the Current and two Future Land Use scenarios.

The CRARE detailed conceptual exposure model is depicted in Figures I.5-1 through I.5-4 (these figures are based on Figures I.1-10 through I.1-13 as presented in Section I.1.6).

I.5.2.1 Sources of Residual Contaminants

This CRARE evaluates the residual human-health risk of the five operable units after remediation, with the focus on Operable Units 1 and 2. Figure I.5-1 presents the post-remediation sources of contaminants and provides a basis for developing the exposure pathways in the conceptual model. The sources, which are described in detail in Sections I.2.2 and I.2.3, include:

- Residual contamination in the remediated areas of each operable unit, including contaminated soil, surface water, groundwater, and vegetation.
- Leachate from disposal facilities for other operable unit material.
- Leachate from capped/covered areas for Operable Units 1 and 2.
- Remediated surface soils.

The conceptual model addresses these sources as reservoirs of residual contaminants that can migrate to other environmental compartments or serve as a direct source of exposure.

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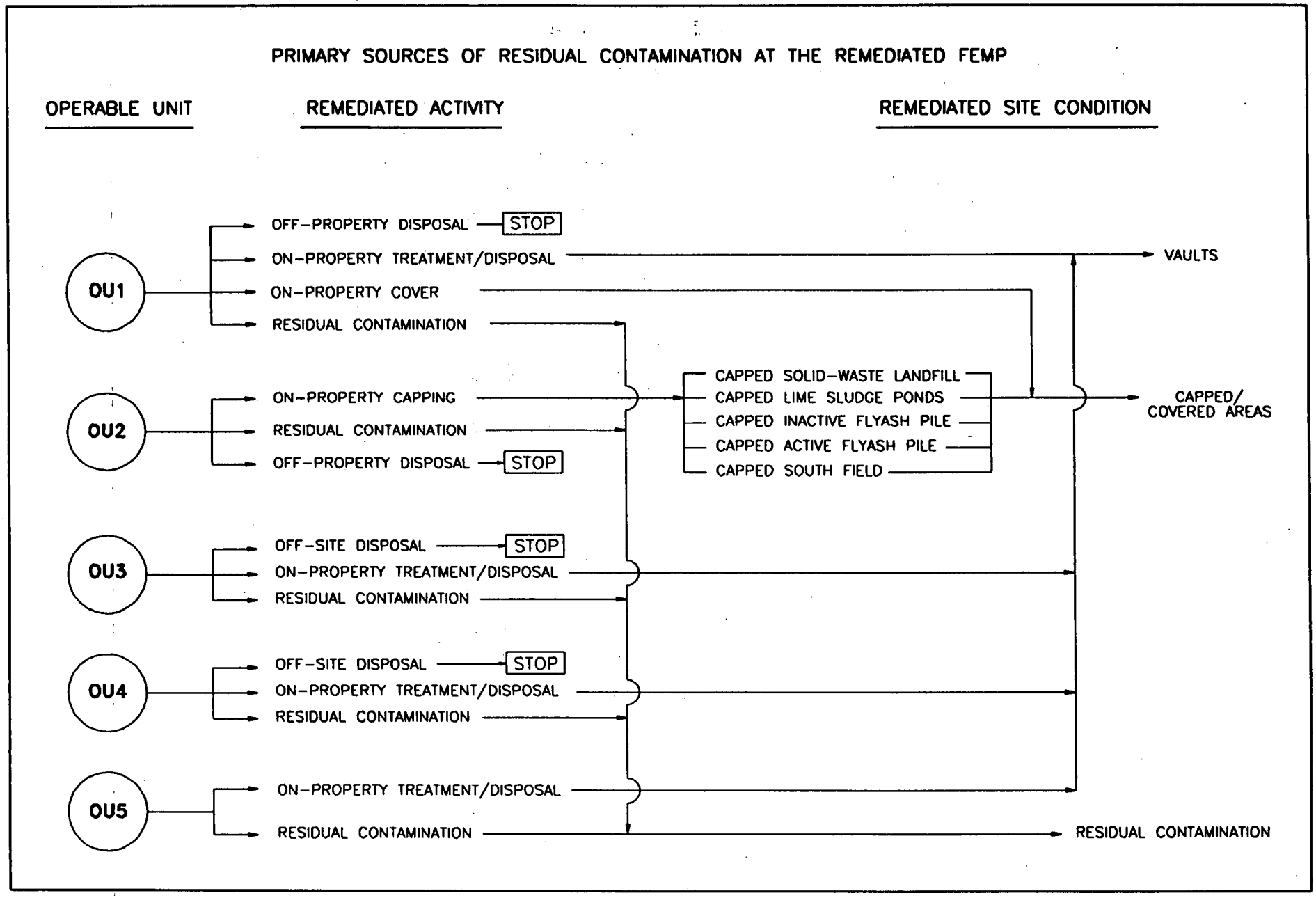

FIGURE 1.5-1

PRIMARY SOURCES OF FEMP RESIDUAL CONTAMINATION

I.5.2.2 Release Mechanisms of Contained Wastes and Soils

Figure I.5-1 outlines the five operable units, and identifies the residual on-property COC sources following the completion of remedial actions. Under the current disposal alternatives, the remediated site will have disposal facility vaults, capped/covered areas, and operable unit footprints with residual wastes that have met the FS remedial objectives and are therefore left at the site (see Figure I.2-1 in Section 2.0).

Capped/covered sources include treated waste and waste material for Operable Units 1, 2, and 3. Uncapped sources include those wastes and soils that, due to their low residual contaminant concentrations, were left within the Operable Unit 1, 2, 4, and 5 footprints (Figure I.5-1). Several mechanisms could allow these latter source contaminants to be accessed directly by a receptor or dispersed and made available for transport in the environment. The following paragraphs describe the hypothetical release mechanisms considered in the CRARE conceptual exposure model (Figures I.5-2 through I.5-4).

Failure of On-Property Disposal Vaults or Capped Structures

This hypothetical release mechanism postulates a failure of the disposal structures holding the treated wastes or a fracture of the capping materials. Once the integrity of these structures is breached, the wastes in or beneath them can be exposed to the environment and subjected to wind erosion, surface runoff, and water infiltration (Figures I.5-2 through I.5-4). Possible forces that can induce structural failure include physical impact or natural weathering forces. These forces can weaken, damage, and/or destroy the integrity of the structures, thus exposing treated or buried materials to the environment. The cap selected for evaluation in this CRARE is designed to remain intact for 1000 years. Therefore, during the entire period of the CRARE risk modeling, releases of bulk materials from disposal facilities or capped areas and direct exposures to contained materials were assumed not to occur. Also during this period, infiltration and leachate generation were assumed to occur, but only in small amounts. An analysis of the proposed disposal facility design was completed and water infiltration/exfiltration and emission venting was calculated due to eventual deterioration.

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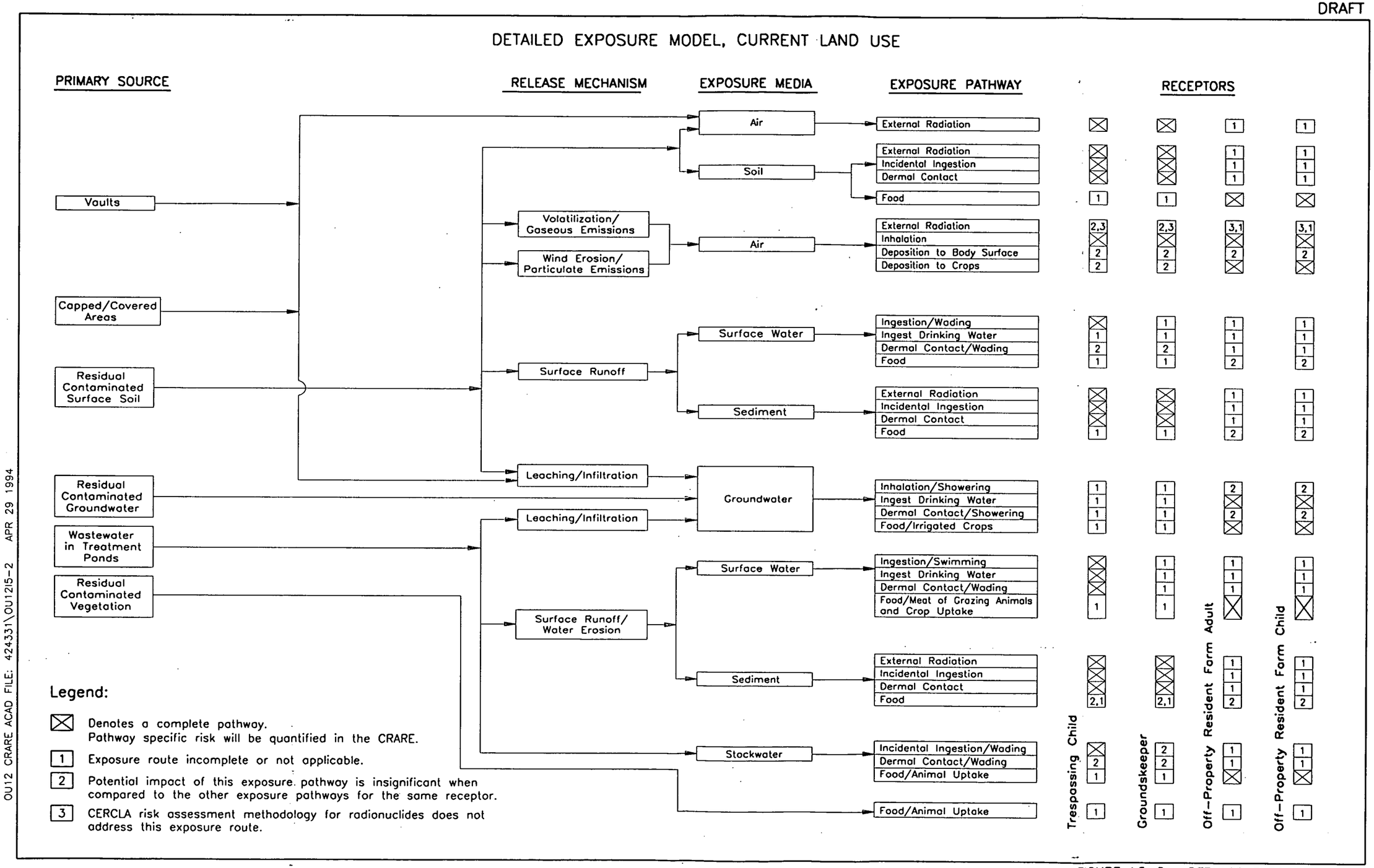

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FIGURE 1.5-2 DETAILED EXPOSURE MODEL, CURRENT LAND USE

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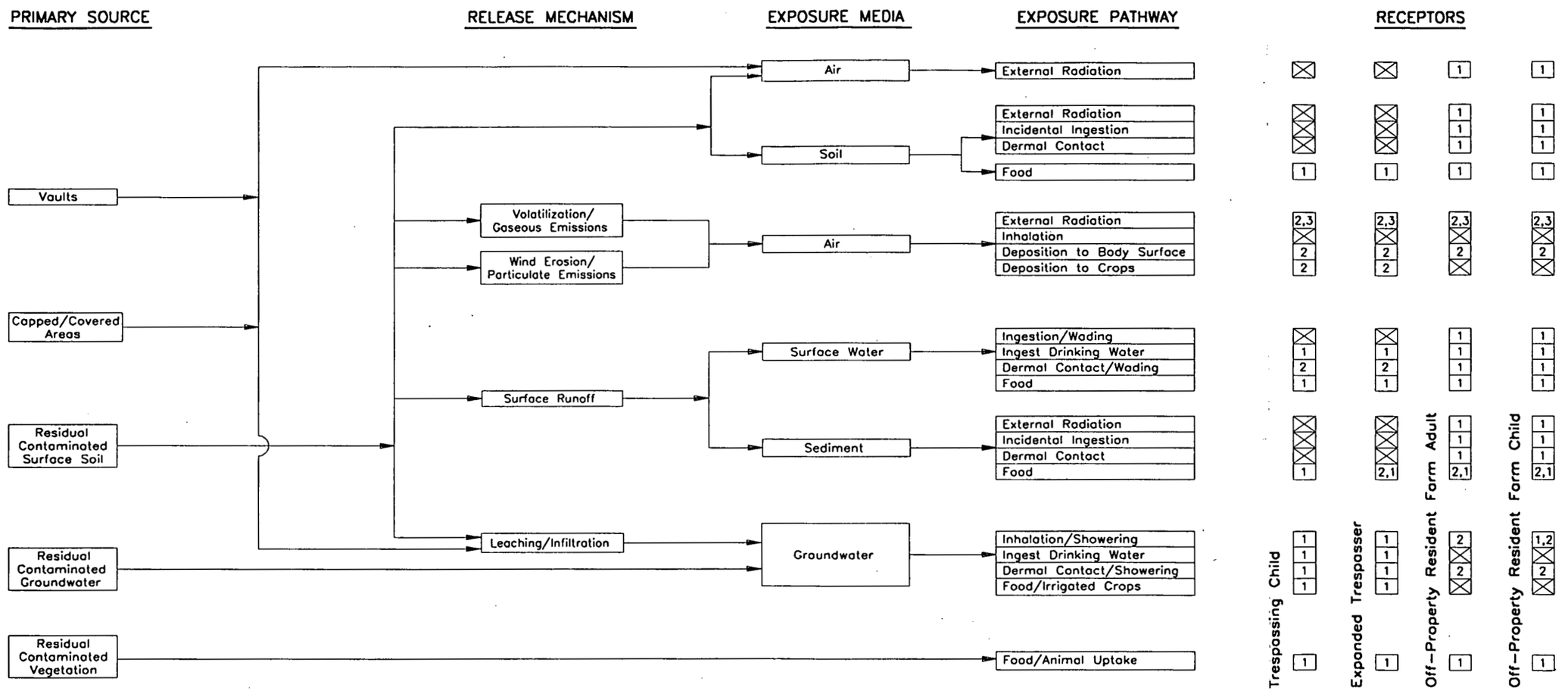
DETAILED EXPOSURE MODEL, FUTURE LAND USE WITH FEDERAL OWNERSHIP



LEGEND:

- ☒ Denotes a complete pathway. Pathway specific risk will be quantified in the CRARE.
- 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 recep
- 3 CERCLA risk assessment methodology for radionuclides does not address this exposure route.

000113

FIGURE 1.5-3 DETAILED EXPOSURE MODEL, FUTURE LAND USE WITH FEDERAL OWNERSHIP

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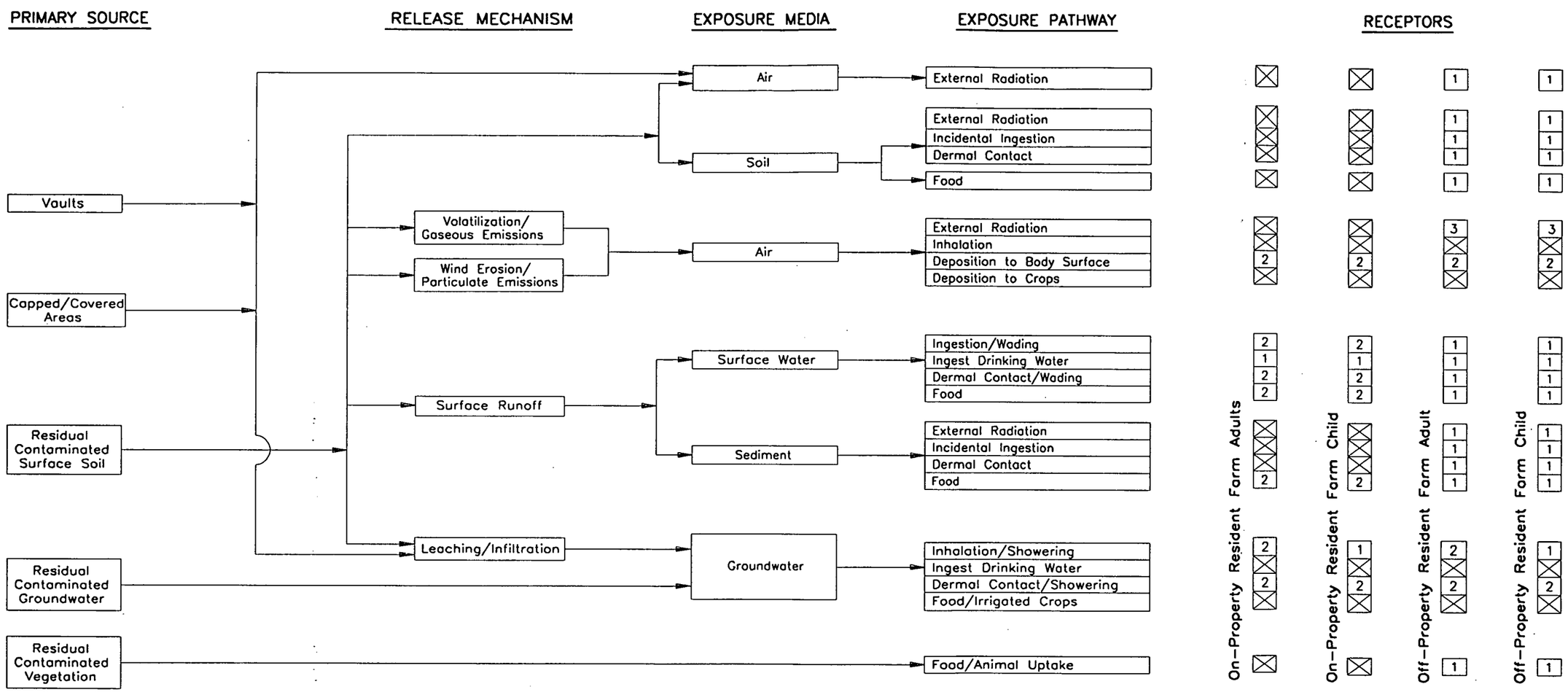
DETAILED EXPOSURE MODEL, FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP



Legend:

- ☒ Denotes a complete pathway. Pathway specific risk will be quantified in the CRARE.
- 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 methodology for radionuclides does not address this exposure route.

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FIGURE 1.5-4 DETAILED EXPOSURE MODEL, FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

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Surface Water Overflow

While the wastewater is being treated at the FEMP during the first 70 years after remediation has been completed (as indicated in the Current Land Use scenario), it is possible that surface water runoff may carry the waste from the designated treatment areas and make it available for human uptake. Specifically, this release mechanism primarily affects water being treated at the wastewater treatment plant or contained in the retaining ponds. These collection structures may overflow during periods of heavy rainfall. The liquid spilling over the top of the treatment plant or ponds can flow overland and contaminate surface soil, sediments, or any water bodies that come in contact with the liquid or receive it.

I.5.2.3 Transport Pathways

Contaminated materials from those sources not contained (residual soils and waste materials, residual groundwater contamination, contaminated vegetation) may be released from the site without the failure of containment structures. Uncontained and contained COCs, if released from the disposal facilities or capped areas, can travel by several transport pathways to reach various environmental media to which potential receptors may be exposed (Figures I.5-2 through I.5-4). This section briefly discusses the four transport pathways.

Air

Releases to air may occur through the generation of particulates by wind or surface soil disturbance. In addition, gaseous phase contaminants may be released through volatilization or radioactive decay (e.g., radon). Transport through the air is expected to be a major pathway for contaminants in residual soils and waste materials left on-property after remediation.

Surface Water and Sediment Runoff

Surface water transports waste material by conveying dissolved and suspended solids to receptors as it flows across the surface of the ground and along any drainage features. It is assumed that no wastes in the capped areas or disposal facilities will be exposed to permit surface sediment runoff. COCs in the surface soils will be subject to transport in surface water/sediment runoff. Runoff can transport contaminants to receiving surface water bodies to which receptors may come in contact directly (through wading, etc.) or indirectly (through stock or irrigation water).

Leaching and Infiltration

The FEMP has a humid climate with an average annual rainfall of about 102 centimeters (40 inches). A portion of this water percolates through subsurface soil and recharges the underlying aquifer. Percolation would also occur through the waste storage structures as a result of the natural weathering process. COCs in waste and soil would be dissolved and transported in this flow. However, degradation, retardation, and radioactive decay may reduce the concentrations that eventually reach the aquifer. Dilution would also occur in the groundwater flow. Eventually, the groundwater would complete the pathway with transport to a well from which a receptor can take water for home and farm use.

I.5.2.4 Exposure Media

The transport pathways just discussed would result in the occurrence of site-related contaminants in the various exposure media identified in Figures I.5-2 through I.5-4. The media to which receptors may be exposed include soil (either in-place residuals or materials transported from source areas by various mechanisms), surface water, sediment, and air. Indirect human exposures to contaminants in one or more of these media may occur through the ingestion of crops or livestock and related products (meat, milk) which have been exposed to contaminated soil or water. In the case of on-property residual soil, no intermediate transport mechanism is necessary for on-property receptors; humans may be exposed directly to in-place materials.

I.5.3 EXPOSURE PATHWAYS

There are numerous potential exposure pathways at the FEMP by which receptors can come in contact with contaminants. These pathways include ingestion, inhalation, and dermal contact with chemical contaminants and radionuclides. In the case of radionuclides, external exposures to radiation may also occur. On the right-hand side of Figures I.5-2 through I.5-4, the various combinations of exposure pathways and exposure media are tabulated. Each pathway and medium are evaluated for each of the exposed receptors under the different exposure scenarios. 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 for the CRARE.

I.5.3.1 Air Exposure Pathways

A receptor's exposure via these pathways begins with wastes being transported by the ambient air, eventually reaching the receptor either by inhalation or external radiation. Inhalation of airborne gases (such as radon) and resuspended particulate is a typical example of this type of exposure. The air exposure pathways are applicable to all on- and off-property receptors examined.

The significance of the air exposure pathway depends on the different characteristics of the receptor's daily activities. These pathways very often are receptor-specific. The significant air exposure pathways identified in this CRARE include inhalation of gases, radon, and resuspended particulate (Figures I.5-2 through I.5-4).

I.5.3.2 Exposure Pathways Attributable to Dermal Contact

This group of pathways encompasses all of the receptor's activities that would result in direct contact with contaminated soil, sediment, and water. Potential sources of contamination for these exposures include exposed waste, soil, and sediment.

Exposure pathways via dermal contact included in the quantitative risk assessment are dermal contact with contaminated soil and sediment (Figures I.5-2 through I.5-4). As in the air exposure pathways described in Section I.5.3.1, many dermal contact exposure routes are receptor-specific.

I.5.3.3 Ingestion Exposure Pathways

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

Eating meat or drinking milk from animals that have ingested contaminated soil, stock water, or foliage while grazing on FEMP property is included in this CRARE risk analysis. Exposure pathways such as ingestion of contaminated soil, surface water, sediment, groundwater, and crops are significant for the receptors investigated in this CRARE (Figures I.5-2 through I.5-4).

I.5.3.4 Exposure to External Radiation

This pathway may be significant for receptors who come into close proximity to residual soils or wastes, such as the trespassing child or groundskeeper under the Current Land Use scenario and the on-property residents or expanded trespasser under the Future Land Use scenarios. Significant external radiation pathways identified for one or more of the receptors include exposure to radiation originating from contaminated soil and sediment.

I.6.0 FATE AND TRANSPORT MODELING

Fate and transport computer models were used to predict the movement of residual contaminants through various media from the remediated FEMP to receptor locations. These models provide the only means of predicting COC concentrations at potential exposure locations because future COC concentration data are, by definition, not available. This CRARE employs model selection approaches, criteria, and modeling parameter values similar to those specified in the RAWPA.

This section describes the methodology used to predict contaminant concentrations in different media for the FEMP Operable Unit 1 & 2 CRARE. Included are discussions of:

- Technical approaches used to select the appropriate model for each potential exposure assessment
- Fate and transport models used
- Required data and default parameter values
- Modeling results

The models were selected based on their appropriateness for a specific application in the CRARE process and the availability of required input information. The principal results from the modeling efforts are predicted concentrations for each COC over a future time period, at specified time intervals, at selected receptor locations. These results are then used as the basis for the risk calculations presented in Section I.9.0. Additional information on the modeling results is also included in the following sections, to supplement the receptor results and increase understanding of the modeling process.

The CRARE models also included assumptions on future FEMP site conditions. These assumed changes were derived primarily from the anticipated remedial actions for each operable unit. Due to the uncertainties associated with these models, all results have been carefully reviewed before including them in this CRARE.

The SWCR contains site-wide modeling that is similar to CRARE modeling. However, the SWCR modeling is intended to evaluate baseline conditions and does not account for changes in

site conditions due to remedial actions. Each operable unit FS is planned to model the effects of all of the remedial alternatives for that operable unit in detail. The CRARE models will be consistent with these efforts by using the same modeling parameters as the FS, but will only address the anticipated PRA or LRA for each operable unit.

One key goal of the CRARE modeling effort is to ensure that all CRAREs use the same input parameters and default values, and that these data are consistent with EPA recommendations. Assumptions and parameters presented in this report may change, subject to EPA approval, as new information becomes available. As discussed in Section I.2.2, the remedial alternatives for some operable units may change in future CRARE documents.

Due to the large number of potential exposure pathways at the FEMP (see Section I.5.0, Figures I.5-1 through I.5-4), the CRARE models have been grouped by transport medium as presented in the RAWPA. Detailed information on the model selection and parameters employed in quantifying fate and transport of contaminants in water are presented in Section I.6.1. This includes vadose zone, surface water and groundwater models. Section I.6.2 presents the air emission and transport models. Section I.6.3 presents modeling methodologies and results for the concentrations of residual contaminants in vegetables, meat, and dairy products.

I.6.1 WATER TRANSPORT MODELING

This section includes a conceptual description of the process of evaluating the groundwater and surface water contaminant transport pathways from source areas to receptors. Detailed discussions then follow on the selection of COCs, the development of source terms for modeling, and the use of vadose-zone, surface-water, and groundwater transport models.

I.6.1.1 Description of Approach

The purpose of water transport modeling was to provide a predictive methodology for simulating the movement of contaminants in surface water, vadose zone water, and groundwater from source areas to receptors. Of the multiple pathways identified in the CRARE Site-Wide Conceptual Model (Section I.1.6), two are described here, surface water and groundwater. The key elements of these and other pathways are:

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- Sources of residual contamination
- Release mechanisms
- Transport pathways
- Exposure pathways
- Receptors

This section provides detailed descriptions of the contaminant sources, release mechanisms and transport pathways, for both the surface water and the groundwater transport pathways, as well as the selection of receptor locations and the development of contaminant concentrations with time at these locations.

Surface water is an exposure medium because receptors were assumed to be located in Paddys Run downstream of the source areas. Surface water in Paddys Run also represents a portion of the groundwater pathway, since COCs in this surface water were assumed to infiltrate to groundwater, and then may be transported in the groundwater to potential receptors. Transport through the vadose zone is also considered to be part of the groundwater pathway. However, perched water is present in the vadose zone beneath some areas of the FEMP, and this water is considered a potential future drinking water supply under some scenarios.

The source areas of groundwater and surface water contamination projected to remain at the FEMP include elements from all operable units. As discussed in Section I.2.2, this CRARE assumed that the PRAs for Operable Units 1, 2, and 4 and the LRAs for Operable Units 3 and 5 would be implemented. When FEMP remediation is complete, the only structures planned to remain on the site are the vaults and capped/covered areas, as described in Section I.2.3 (Figure I.2-1). In addition, a water treatment facility was assumed to be present in the Current Land Use scenario. Per the PRAs, waste from Operable Units 2, 3, and 4 would be capped or disposed in vaults. The vaults along the eastern boundary of the FEMP (the Eastern Vaults) were assumed to contain Operable Unit 3 waste plus soil and rubble from Operable Unit 4. The Solid-Waste Landfill, Lime Sludge Ponds, Inactive Flyash Pile, Active Flyash Pile, and South Field areas of Operable Unit 2 were assumed to be consolidated and capped in place. Other source areas include the site-wide soil under Operable Unit 5, the residual soils within the Operable Unit 4 boundary, and the covered and residual Operable Unit 1 areas.

Figure I.6-1 shows the process, in conceptual terms, of evaluating the surface water and groundwater pathways. The CRARE Site-Wide Conceptual Model is described in Section I.1.6 and throughout this CRARE. The FEMP Conceptual Flow Model is the current, comprehensive, and consistent description of the hydrogeologic environment at the FEMP. This conceptual model is described in the SWCR and most recently in the Operable Unit 5 RI report (DOE 1994c). The conceptual model is an approximation and simplification of actual field conditions and is subject to modification as additional field data are developed. The data and interpretations presented in the SWCR and Operable Unit 5 RI report are briefly described and referenced below.

The CRARE Site-Wide Conceptual Model (Section I.1.6, Figures I.1-11 through 13) includes leachate as a release mechanism of concern for all of the primary sources. Figure I.6-1 shows the steps involved in estimating the flow rates and COC concentrations with time of the leachate from each of the source areas. Rainwater was the only source of inflowing water considered in the CRARE for the formation of leachate. Agricultural irrigation, residential watering, or industrial discharges were assumed not to occur at contaminated areas at the FEMP within the modeled period. The HELP Infiltration Model (as described in the SWCR) was used to estimate soil infiltration and runoff rates. Previous geochemical studies (using a geochemical model, EQ3/6), literature research, and a limited amount of bench-scale laboratory leach test data were used to estimate COC concentrations in the leachate.

The leachate data was then used as input to the vadose zone transport modeling. The ODAST model was used to mathematically simulate flow and transport through the vadose zone from each of the source areas. The time-variant output from ODAST was used as input to the SWIFT III groundwater model, which had previously been calibrated to simulate the current flow and contaminant characteristics at the site. Model calibration is discussed in ASI/IT (1990a) and IT (1990a).

Contaminant transport was simulated in the SWIFT III model over a rectangular area that is a subset of the area covered by the groundwater flow portion of the model. A grid system subdivides the transport area into 112 by 120 squares (Figure I.6-2). A smaller grid was originally

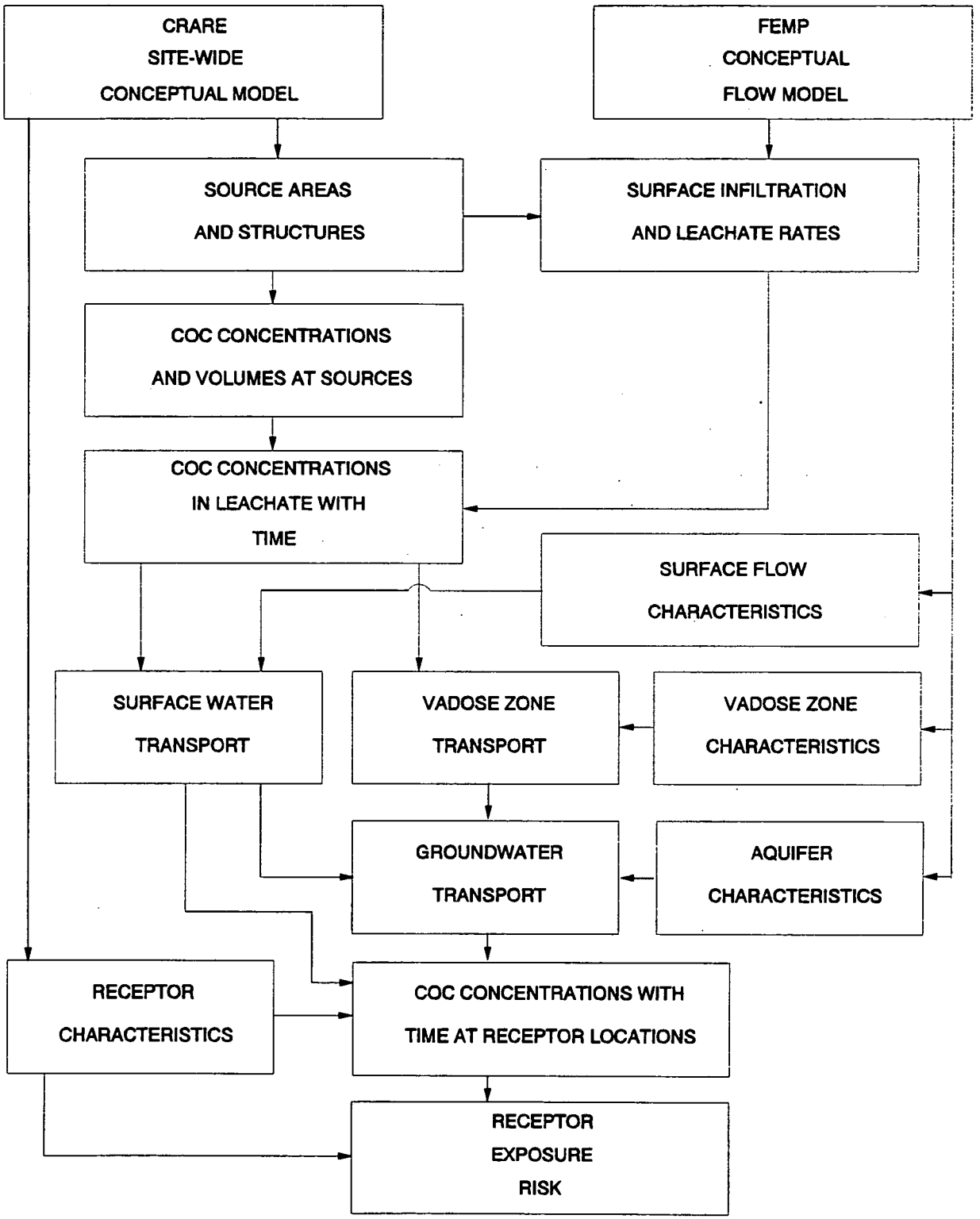

FIGURE I.6-1

EVALUATION OF SURFACE WATER AND GROUNDWATER PATHWAYS

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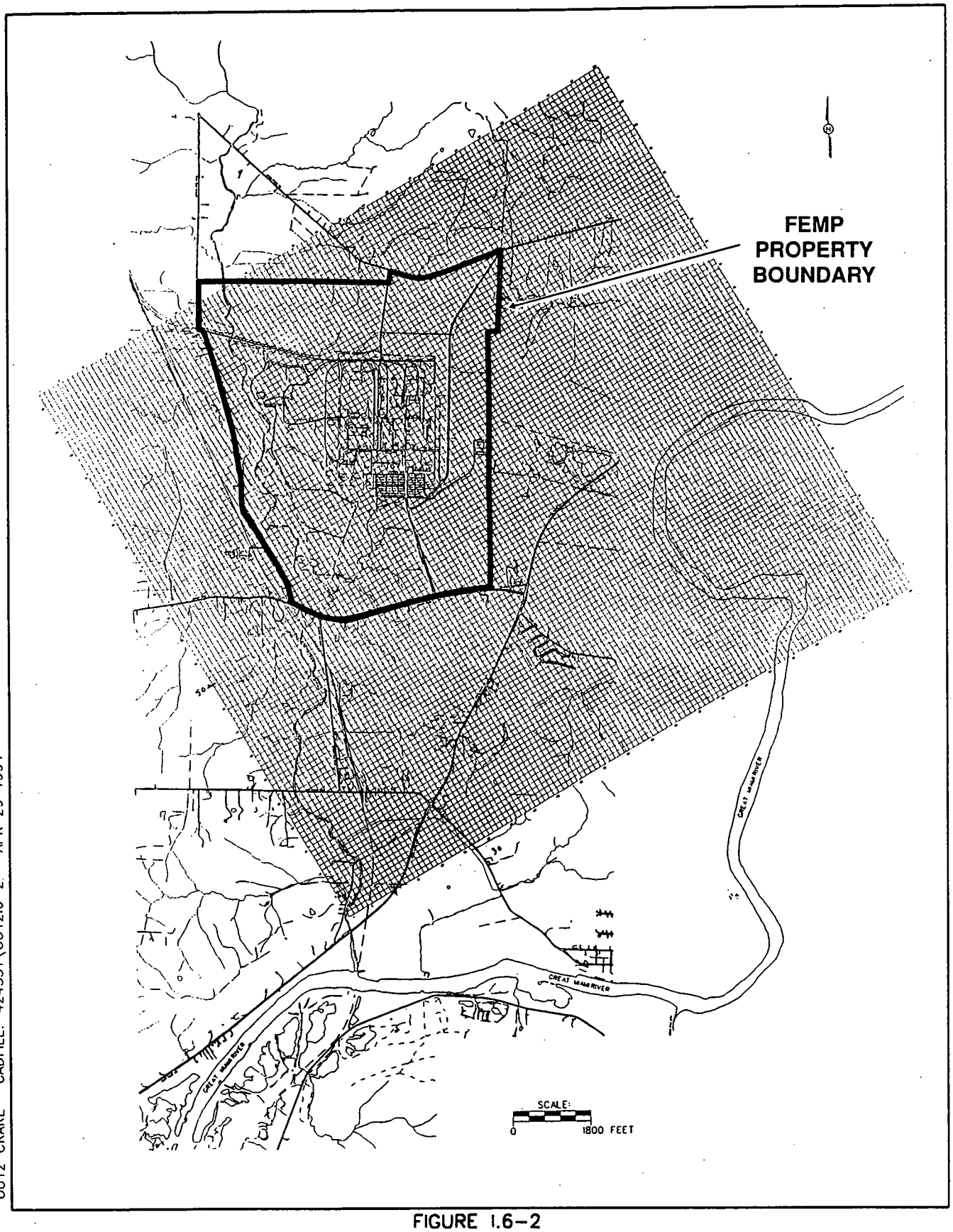

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FIGURE 1.6-2
REVISED FLOW AND SOLUTE GRID

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established in the SWCR to simulate the currently existing uranium plume in the groundwater. The new grid was developed to expand the coverage for all of the RI/FS studies.

The transport grid squares were used in this CRARE to define the areas of source terms and vadose zone transport modeling. This made the process of defining the COC input terms for the groundwater model more efficient, since the same area definitions were carried through the multiple modeling steps.

I.6.1.2 Screening of COCs

Section I.4.0 describes how a site-wide list of potential COCs was compiled for possible inclusion in the CRARE and then reduced through three screening procedures. Table I.4-6 (Section I.4.5) presents the final site-wide list of COCs retained after the screenings.

Additional screening of the COC list for the groundwater pathway was done, prior to determining source terms, to remove those COCs from the list that are predicted to not be transported in significant quantities by ODAST through the vadose zone within 1000 years. Retardation factors for COC transport were primarily used to establish this for the Operable Unit 3 and 5 areas. For Operable Units 1, 2 and 4, a review of their respective FS groundwater modeling results was conducted to determine the most significant COCs. Those COCs for which the number of sampling results were too limited to estimate a total mass were not analyzed further because the results would not be meaningful. This does not represent an assumption that these compounds are present in negligible quantities, but only that not enough information was available on which to base a meaningful analysis. However, they may be included in future CRAREs. The screening was done to reduce the computational time required for the vadose zone modeling.

The remainder of this section describes the screening process, including a listing of COCs eliminated and retained for the groundwater pathway.

The screening method for the Operable Unit 3 and 5 areas employed a preliminary travel time screening. The basis of the travel time screening was that the concentration fronts of certain COCs, because of retardation by sorption, will not migrate through the vadose zone and reach the aquifer in 1000 years. Consequently, these COCs will not contribute to risk in the first 1000 years

and can be eliminated from the analysis. The front was defined in such a manner that no significant amount of the COC is predicted to leave the vadose zone before the appearance of the front. The specific procedure for the travel-time screening is described below. Groundwater recharge from Paddys Run and the storm sewer outfall ditch, which have direct contact with the Great Miami Aquifer, were excluded from this screening.

The variables used in the screening step are minimum retardation factor (R_{min}) in the vadose zone, soil thickness (L), seepage velocity (V), and the axial dispersion coefficient (D_L). The soil thickness was taken as the distance from the top of the perched zone to the bottom of the glacial till. These materials were considered to be saturated. Data on all of these variables are provided in the SWCR. The mean travel time (t_m) of the concentration front through the vadose zone for a nondecaying COC can be calculated from the first three variables as:

$$t_m = R_{min}\, L/V \qquad (1)$$

A characteristic dispersion parameter can also be calculated as:

$$N_D = D_L/VL \qquad (2)$$

A fraction (M) can then be estimated to give a time before which the exiting concentrations will be negligible. The "M" factor must be used to compensate for the fact that some contamination will arrive before the mean travel time (t_m) because of dispersion. For example, if there is no dispersion (i.e., plug flow), M would equal one because, theoretically, the response front would be a square wave with a vertical rise from 0 to the maximum concentration at t_m. Brenner (1962) gives an analytical solution for a non-decaying solute with linear-equilibrium sorption (the ODAST assumption). Brenner provides extensive tabular output for the response front concentrations as a function of non-dimensional time (time/t_m) with N_D varied parametrically. The value for M is that value of non-dimensional time selected from the applicable N_D curve such that the front concentration is less than 10^{-4} times the peak concentration. The higher the value of N_D the more relatively important is dispersion and the lower M must be to assure that significant concentration would not escape from the vadose zone. Consequently, as infiltration velocity is decreased by capping, etc., dispersion becomes relatively more important because velocity is in the denominator of the N_D term. Thus M for capped areas, etc. is low. M factors

determined from the curves in Brenner (1962) were 0.1 for the Operable Unit 3 vaults, and 0.5 for the Operable Unit 3 soil area.

If Mt_m is set at 1000 years, exiting concentrations prior to 1000 years will be negligible. This can also be expressed as:

$$t_m = 1000/M. \quad (3)$$

Since R_{min} is defined as:

$$R_{min} = t_m V/L, \quad (4)$$

a minimum screening retardation factor,

$$R_s = 1000 \times V/ML, \quad (5)$$

can be defined above which the mean travel time will be in excess of 1000/M years, and exiting concentrations for up to 1000 years will be negligible. The R_s was calculated for each COC and compared to its R_{min} to determine if the COC could be screened out. This analysis is conservative in that one dimensional flow was assumed, the minimum retardation factor that occurs in any vadose layer was used, and any depletion by biodegradation or decay was ignored.

Table I.6-1 illustrates the results of the travel-time screening for potential groundwater COCs. The areas used in this screening were Operable Unit 3 and the Eastern Vaults (containing the Operable Unit 3 waste). "Retained" in any column means the COC was not screened out. "Screened Out" means that the constituent was not expected to reach the aquifer in 1000 years, and that it was deleted from further consideration. "Not Determined" means that values of the retardation factor were not available to permit calculation of travel times. However, the COCs identified as "Not Determined" (the chlorodibenzofurans and heptachlorodibenzo-p-dioxin) were not analyzed further because the sampling data are too limited to define a source term for mass. They were also screened out for the groundwater pathway in the Operable Unit 5 RI report (Appendix A, Baseline Risk Assessment; Attachment A.VII, Incremental Lifetime Cancer Risks and Chronic Hazard Indices).

In summary, the COCs identified with "Screened Out" or "Not Determined" in all columns of Table I.6-1 were eliminated from the groundwater pathway; and the uranium isotopes, Tc-99,

TABLE I.6-1

SCREENING OF COCs FOR THE GROUNDWATER PATHWAY[a]

COCs	OU3	E Vault
Radionuclides		
Ac-227	Screened Out	Screened Out
Am-241	Screened Out	Screened Out
Cs-137	Screened Out	Screened Out
Np-237	Screened Out	Screened Out
Pa-231	Screened Out	Screened Out
Pb-210	Screened Out	Screened Out
Pu-238	Screened Out	Screened Out
Pu-239/240	Screened Out	Screened Out
Ra-226	Screened Out	Screened Out
Ra-228	Screened Out	Screened Out
Ru-106	Screened Out	Screened Out
Sr-90	Screened Out	Retained
Tc-99	Retained	Retained
Th-228	Screened Out	Screened Out
Th-230	Screened Out	Screened Out
Th-232	Screened Out	Screened Out
U-233	Retained	Retained
U-234	Retained	Retained
U-235	Retained	Retained
U-235/236	Retained	Retained
U-238	Retained	Retained
Organics		
1,2,3,6,7,8-Hexachlorodibenzofuran	Not Determined	Not Determined
2-Chlorophenol	Retained	Retained
2-Methylnapthalene	Screened Out	Screened Out
4-Chlorophenyl-phenylether	Screened Out	Screened Out
4,4-DDE	Screened Out	Screened Out
Aroclor-1016	Screened Out	Screened Out
Aroclor-1221	Screened Out	Screened Out
Aroclor-1242	Screened Out	Screened Out

See footnotes at end of table.

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TABLE I.6-1
(Continued)

COCs	OU3	E Vault
Organics (cont.)		
Aroclor-1248	Screened Out	Screened Out
Aroclor-1254	Screened Out	Screened Out
Aroclor-1260	Screened Out	Screened Out
Benzo(a,h)anthracene	Screened Out	Screened Out
Cyanide	Retained	Retained
Di-n-octylphthalate	Screened Out	Screened Out
Heptachlorodibenzofuran	Not Determined	Not Determined
Heptachlorodibenzo-p-dioxin	Not Determined	Not Determined
Octachlorodibenzofuran	Not Determined	Not Determined
Inorganics		
Antimony	Screened Out	Screened Out
Arsenic	Screened Out	Screened Out
Barium	Screened Out	Screened Out
Beryllium	Screened Out	Screened Out
Cadmium	Screened Out	Screened Out
Chromium	Screened Out	Screened Out
Cobalt	Screened Out	Screened Out
Copper	Screened Out	Screened Out
Lead	Screened Out	Screened Out
Manganese	Screened Out	Screened Out
Mercury	Screened Out	Screened Out
Molybdenum	Screened Out	Screened Out
Nickel	Screened Out	Screened Out
Selenium	Screened Out	Screened Out
Thallium	Screened Out	Screened Out
Vanadium	Screened Out	Screened Out
Zinc	Screened Out	Screened Out

[a] Definitions:

Screened Out	=	COC eliminated from further consideration (not expected to reach aquifer in 1000 years).
Retained	=	COC not screened out.
Not Determined	=	COC not analyzed further (sampling data too limited to define source term).

Sr-90, cyanide, and 2-chlorophenol passed this screening. However, the previous CRARE found that Tc-99, Sr-90, cyanide and 2-chlorophenol did not make a significant contribution to risk.

The screening method for the Operable Unit 1, 2, and 4 areas involved a review of the groundwater modeling and risk assessment results for the PRA in the FS for each operable unit. The FS for Operable Unit 1 identified the uranium isotopes, Tc-99, Np-237, Aroclor-1254, antimony, and cadmium as representing potential risks by the groundwater pathway above the CRARE screening levels of 1×10^{-7} for ILCR or 1×10^{-1} for HI. A subsequent review of the modeling data for Operable Unit 1 determined that "Aroclor-1254" is a misprint in the FS, and the correct compound is Aroclor-1221.. The FS documents for Operable Units 2 and 4 found that only the uranium isotopes and Tc-99 (for Operable Unit 2) were of concern.

Therefore the COCs retained for ODAST and then SWIFT III modeling are the uranium isotopes, Tc-99, Np-237, Aroclor-1221, antimony, and cadmium. Because of their chemical similarity, all of the uranium isotopes were assumed to be transported by water in approximately the same manner. Therefore, U-238 is the only uranium isotope that has been modeled for this CRARE, since it is the most abundant isotope. The other isotopes were assumed to also be transported in the same ratios to U-238 as they are present in the source areas. The relative abundances of the uranium isotopes at the FEMP are as follows, in decreasing order:

- U-238 99.3 percent
- U-235 0.685 percent
- U-236 9.63×10^{-3} percent
- U-234 8.96×10^{-3} percent

These values were estimated from the uranium isotope distributions found in the RI/FS database.

I.6.1.3 Descriptions of Source Terms

Section I.6.1.1 describes how this CRARE uses the PRAs for Operable Units 1, 2, and 4 and the LRAs from the SWCR for Operable Units 3 and 5 to identify the source areas assumed to remain after remediation. These assumptions provide the basis for determining the locations and source terms for the release of COCs to the water pathways. Descriptions of the Operable Unit 1, 2, and 4 source areas are not included in this section, since they are described in the FS reports for those units. Operable Unit 2 subdivided the South Field and Inactive Flyash areas into a complex

pattern of eight zones that define groundwater source terms. Detailed information on these zones is presented in the Operable Unit 2 FS report (Appendix D, Table D.3-8). The individual source terms and results for these zones are only summarized in this CRARE. The Lime Sludge Ponds and Active Flyash Pile are not included as source areas because the Operable Unit 2 FS concluded that for the PRA, they will not be significant sources to groundwater.

I.6.1.3.1 COC Masses and Leachate Concentrations

The determination of COC masses, initial concentrations, and the derived leachate concentrations for each of the Operable Unit 3 and 5 source areas is described below. The estimation of infiltration rates as part of the source terms is described in Section I.6.1.3.2 and I.6.1.3.3. The calculation of rainfall runoff as a source term to surface water flow is described in Section I.6.1.5.

Under Operable Unit 5, the area of potential soil contamination includes the entire FEMP (Section I.2.2, Figure I.2-1). The areas for Operable Units 1, 2, and 4 were not included in the CRARE site-wide soils area because they are described separately as sources of COCs. The vaults were not included because the soils in these areas will be excavated for foundation construction. Operable Unit 1 intends to transfer approximately 58,645 cubic meters (76,700 cubic yards) of potentially contaminated soil to Operable Unit 5 for treatment and eventual disposal in an Operable Unit 5 area. Possible COC concentrations in this soil have not been included in the Operable Unit 5 totals because these concentrations have not been estimated by Operable Unit 1, the soil will be treated, and the volume is small compared to the total volume of soil within Operable Unit 5. This transferred soil will be addressed in the Operable Unit 5 CRARE.

Soils within the Operable Unit 3 Production Area were generally expected to contain elevated levels of uranium, unless sampling results show otherwise. Soils outside the operable unit or vault boundaries, but within the FEMP, were assumed to have background levels of uranium unless analytical results were available to indicate the location and magnitude of contamination. Figure I.6-3 presents the grid squares where elevated levels of uranium are believed to be present in the soils. The Main Plant area includes subdivisions for Plant 2/3, Plant 6, and Plant 9. The forms of uranium and geochemical conditions are different in these three subareas than in the remainder of the Main Plant area (Lee and Marsh 1992). For other COCs, the Operable Unit 3 area was

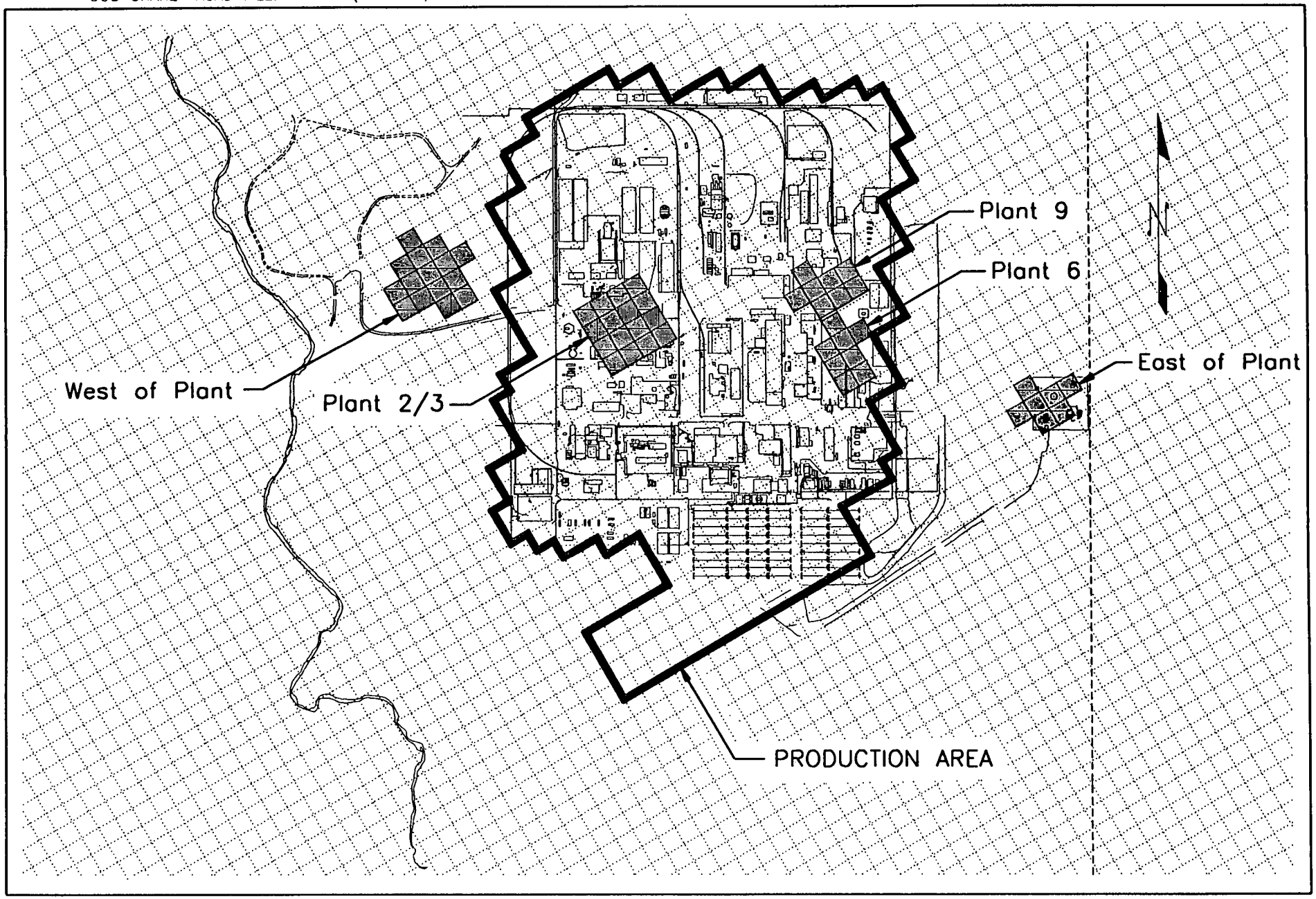

FIGURE 1.6-3
GRID LOCATIONS OF ELEVATED URANIUM IN FEMP SOILS

also assumed to be at background levels unless analytical results indicated otherwise. Only COCs in soils within the FEMP boundary were evaluated for this CRARE.

Data on the concentrations and extent of the COCs in soils were obtained from the RI/FS database. Plant 2/3, Plant 6, and Plant 9 areas have the deepest vertical extent of soil contamination in the Production Area. The estimated vertical extent of U-238 contaminated soil is 3 meters (10 feet) in the Plant 2/3, Plant 6, and Plant 9 subareas; and 1 meter (3 feet) for the remaining area. For U-238, all concentrations above 60 pCi/g were assigned that value to represent the results of the soil-washing remediation of Operable Unit 5. The 60-pCi/g cleanup level for U-238 was selected from the SWCR. Similarly, soil washing cleanup levels of 36,600 pCi/g for Tc-99 and 5 pCi/g for Np-237 were selected by Operable Unit 5 from SWCR data. However, these values may be changed in future CRARE documents, depending on the results of treatability tests being conducted for the Operable Unit 5 soil-washing process.

Residual soil concentrations were separately defined for each subarea. Inside the Plant 2/3, Plant 6, and Plant 9 subareas, the majority of the soil is higher than the U-238 cleanup level, and therefore the assumption was made that all of this soil would be washed. The 60-pCi/g level was defined as the residual U-238 concentration for these three subareas.

For the remaining portion of the Main Plant area, plus the west-of-plant and east-of-plant areas, only a portion of the soil is higher than the U-238 cleanup level and will require soil washing. Individual concentration values in the database above 60 pCi/g were assigned that value as representing washed soil. Concentrations below 60 pCi/g were assumed to remain the same (unwashed soil). Similarly, individual values in the database for the other COCs that were above their cleanup level values were assigned that value as representing washed soil.

The database for each COC was then divided into two groups: 1) "surface results," which are analytical results from soil samples collected from the surface to 15.2 centimeters (6 inches) in depth and 2) "subsurface results," which are analytical results from below 15.2 centimeters (6 inches). The 0-to-15.2 centimeter (0-to-6 inch) depth was selected because many of the surface soil samples in the database had been collected within that range. The surface soil databases were used to estimate COC source locations, soil concentrations, and masses for the

surface water modeling. The subsurface soil databases were used for the same purposes for the vadose zone modeling. For each database the soil concentrations were averaged over depth and gridded on the SWIFT transport grid to obtain cell by cell concentrations. If analytical results were not available for soils in a cell, then the COC concentrations in that cell were assumed to be negligible. The assumption was also made that only 30 percent of the uranium in the untreated residual soils would be available for desorption and transport. For the washed soils, only 5 percent of the remaining uranium was assumed to be available for desorption and transport. These assumptions are based on soil washing tests conducted by Oak Ridge National Laboratory. They are discussed further in Attachment I.V. Uranium was the only COC for which reductions were made in the available mass for transport because soil washing data were not available for the other COCs. The process of evaluating the areas where there is soil data for the COCs followed four steps:

1. Average all sample results at each particular location over depth.
2. Average the depths over which contamination penetrated.
3. Grid the average results over the desired portion of the SWIFT solute transport grid. Use the "inverse distance" algorithm of SURFER (Golden Software, Inc. 1990).
4. Take the arithmetic average of the gridded results.

The leachate concentrations from the averaged soil results were obtained by dividing the soil concentration by the soil partitioning coefficient (K_d) for the COC. This approach assumes that the soil and the water passing through it are in reversible linear equilibrium with each other (the same assumption that SWIFT makes). This assumption does not take into account the effects of variations in pH, anions, and mineralogical composition on COC partitioning. The lower the flow of water, the more accurate is this assumption. Accuracy is also improved by having dilute concentrations well below solubility limits. K_d values used for the CRARE modeling are discussed further in Sections I.6.1.4.1 and I.6.1.6.1, and in Attachment I.V. A comprehensive list of K_d values for the FEMP appears in the RAWPA, which also describes their derivation. K_d is defined as the mass of solute on the soil solid per unit mass of solid, divided by the concentration of solute in solution. The leachate concentrations and masses of COCs for the Operable Unit 3 wastes in the Eastern Vaults were taken from the SWCR.

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To summarize the results of this section, the mass values and initial leachate concentrations for each COC at each of the source areas are listed in Table I.6-2. These source terms were used as input to the vadose-zone transport modeling described in Section I.6.1.4. Residual uranium in the perched water of the vadose zone at the end of remediation will eventually be transported down to groundwater. The mass of this uranium is listed in Table I.6-2 and discussed in Section I.6.1.4.1. The input to the surface water transport modeling is listed separately in Section I.6.1.5. Residual uranium projected to remain in groundwater at the end of remediation is discussed in Section I.6.1.6.1. Masses for isotopes other than U-238 are not shown in Table I.6-2 but were estimated by multiplying the U-238 masses by the ratios provided in Section I.6.1.2.

I.6.1.3.2 Soil and Capped Area Infiltration Rates

Section I.2.3.3 describes the types of covers to be constructed over the Operable Unit 1 and 2 areas. HELP model simulations of these designs were run by each operable unit, and the resulting infiltration rates are listed in Table I.6-3. The infiltration rate for the Operable Unit 4 residual area was determined by Operable Unit 4.

For the site-wide soils, information regarding the major portion of Production Area soils in the SWCR was used. The percolation rate of 19.1 cm/year (7.5 in./year) was determined from the seepage velocities given in Appendix O of the SWCR. This rate was originally developed by HELP modeling of surface soils. Operable Unit 5 has made the assumption that the infiltration rate through the washed and back-filled soil in localized areas (i.e., Plant 2/3, Plant 6, and Plant 9) will be reduced by up to one order of magnitude, if determined necessary. This reduction of infiltration can be achieved by vegetation, compacting the back-filled soil, and mixing the back-filled soil with low permeability materials. Therefore, the infiltration rate for these three areas was set at 1.9 cm/year (0.75 in./year). This assumption is discussed further in Attachment I.V.

I.6.1.3.3 Vault Infiltration Rates

This section summarizes an investigation of concrete vault degradation conducted for this CRARE to identify significant design factors and estimate infiltration rates through the Eastern Vaults. Radon gas emissions from the vaults are addressed in Section I.6.2.5. A literature review found that groundwater flow through concrete vaults has been the subject of several research efforts, and that a wide range of modeling procedures based on many parameters are available.

TABLE I.6-2

SOURCE TERMS FOR COC MASSES AND CONCENTRATIONS

Source Area	Total Initial Mass (mg)	Initial Mobile Mass (mg)	Initial Leachate Concentration (mg/l)	Calculation Method
U-238				
Eastern Vaults	2.635×10^{12}	2.635×10^{12}	3.289×10^{-3}	SWCR
OU4 Contaminated Soils	1.083×10^{7}	1.083×10^{7}	1.500×10^{0}	OU4 FS
OU1 Contaminated Soils	2.876×10^{10}	2.876×10^{10}	7.440×10^{-1}	OU1 FS
OU2				
South Field and Inactive	1.262×10^{10}	1.262×10^{10}	1.503×10^{1}	OU2 FS
Perched Water	3.946×10^{7}	3.946×10^{7}	7.649×10^{-1}	OU2 FS
Site-Wide Soils				
Main Plant Area				
Plant 2/3	1.865×10^{10}	9.325×10^{8}	5.563×10^{-1}	Database Kd
Plant 6	9.324×10^{9}	4.662×10^{8}	5.563×10^{-1}	Database Kd
Plant 9	9.324×10^{9}	4.662×10^{8}	5.563×10^{-1}	Database Kd
Remainder	1.468×10^{10}	4.403×10^{9}	2.553×10^{-2}	Database Kd
East Plant Area	8.160×10^{9}	4.080×10^{8}	5.563×10^{-1}	Database/Kd
West Plant Area	1.748×10^{10}	8.742×10^{8}	5.563×10^{-1}	Database/Kd
Perched Water	6.968×10^{6}	6.968×10^{6}	2.010×10^{-1}	1000-Series
Tc-99				
Eastern Vaults	2.615×10^{4}	2.615×10^{4}	1.055×10^{-3}	SWCR
OU1 Contaminated Soils	8.220×10^{4}	8.220×10^{4}	4.337×10^{-3}	OU1 FS
OU2 Solid Waste Landfill	1.524×10^{7}	1.524×10^{7}	1.760×10^{-6}	OU2 FS
Site-Wide Soils				
Main Plant Area	1.818×10^{5}	1.818×10^{5}	1.055×10^{-3}	Database/Kd
East Plant Area	2.383×10^{3}	2.383×10^{3}	1.055×10^{-3}	Database/Kd
West Plant Area	5.107×10^{3}	5.107×10^{3}	1.055×10^{-3}	Database/Kd
Np-237				
OU1 Contaminated Soils	1.140×10^{5}	1.140×10^{5}	1.289×10^{-5}	OU1 FS
Site-Wide Soils				
Plant 2/3	2.248×10^{5}	2.248×10^{5}	4.681×10^{-4}	Database/Kd
Plant 6	1.241×10^{5}	1.241×10^{5}	5.579×10^{-4}	Database/Kd
Cadmium				
Eastern Vaults	8.895×10^{8}	8.895×10^{8}	$1.167 \times 10^{+2}$	SWCR
OU1 Contaminated Soils	9.319×10^{8}	9.319×10^{8}	1.160×10^{-2}	OU1 FS
Site-Wide Soils				
Plant 2/3	1.835×10^{8}	1.835×10^{8}	7.800×10^{-3}	Database/Kd
Plant 9	1.435×10^{8}	1.435×10^{8}	1.220×10^{-2}	Database/Kd
Remainder	4.176×10^{9}	4.176×10^{9}	8.142×10^{-3}	Database/Kd

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TABLE I.6-2
(Continued)

Source Area	Total Initial Mass (mg)	Initial Mobile Mass (mg)	Initial Leachate Concentration (mg/l)	Calculation Method
Antimony				
Eastern Vaults	4.618×10^{9}	4.618×10^{9}	$1.451 \times 10^{+0}$	SWCR
Site Wide Soils				
Plant 6	3.215×10^{8}	3.215×10^{8}	4.085×10^{-2}	Database/Kd
Plant 9	7.985×10^{7}	7.985×10^{7}	1.015×10^{-2}	Database/Kd
Remainder	8.539×10^{9}	8.539×10^{9}	2.489×10^{-2}	Database/Kd
OU1 Contaminated Soils	4.371×10^{9}	4.371×10^{9}	1.088×10^{-1}	Database/Kd
Aroclor-1221				
Eastern Vaults	1.322×10^{7}	1.322×10^{7}	8.112×10^{-2}	SWCR
Site-Wide Soils				
Plant 2/3	2.200×10^{8}	2.200×10^{8}	1.222×10^{-2}	Database/Kd
Plant 9	1.163×10^{7}	1.163×10^{7}	1.292×10^{-3}	Database/Kd
Remainder	2.701×10^{8}	2.701×10^{8}	6.880×10^{-4}	Database/Kd

TABLE I.6-3
INFILTRATION RATES

Source Area	Infiltration Rate (in./yr)
Eastern Vaults	5.118×10^{-1}
OU4 Residual Area	6.0000×10^{0}
OU1 Covered Area	9.1×10^{-1}
Remainder	7.5×10^{0}
OU2	
Solid Waste Landfill	1.14×10^{0}
South Field and Inactive Flyash Pile	1.22×10^{0} to 9.61×10^{0}
Site-Wide Soils	
Main Plant Area	
Plants 2/3, 6 and 9	7.500×10^{-1}
Remainder	7.5000×10^{0}
East Plant Area	7.5000×10^{0}
West Plant Area	7.5000×10^{0}

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The underlying assumptions, key parameters, and processes that affect permeability are discussed in this section. Typical flow rates through vaults are then presented, along with membrane flaws and their effects. To develop a reasonable estimate of leakage, key assumptions were made:

- Maintenance of the vaults will stop after approximately 70 years.
- Concrete mix will be proportioned to minimize degradation and permeability.
- A geosynthetic membrane will be used that will completely deteriorate after 500 years.
- A perched water table on the top of the vaults will create an average annual pressure head of 10 centimeters (3.9 inches).
- Water entering the vaults will equal water exiting the vaults.

Permeability, resistance to degradation, and aging of concrete are directly related to the original mix. Mixing properties that affect the pertinent qualities of concrete include:

- The water-to-cement ratio
- The addition of pozzolanic materials
- The addition of superplasticizers
- Curing techniques
- Prestressing and post-tensioning

Configuration, layout of the vault, and natural processes are difficult to characterize but very important when considering the permeability of the vaults. Factors needing to be considered include:

- The drainage pattern of the site
- The connection details of roofing panels
- The infiltration of silts, clay, and other material that may fill the cracks.
- Expansive reactions in the concrete that could close up some of the cracks

Some factors that affect degradation and permeability of the concrete are:

- Sulfate attack
- Chloride ions corroding the reinforcing steel
- Alkali-aggregate reactions
- Alkali-carbonate reactions
- Freezing and thawing effects
- Microbiological attack, salt crystallization, and attack by radiation
- Creep and shrinkage of concrete
- Relaxation and stress relief in post-tensioning cables

- Inherent brittleness of low water/cement ratios in impermeable concrete mixes
- Cracking due to impact of placing backfill over vault
- Differential settlement of soil beneath of vaults

Of all these variables and mechanisms, only a few can actually be modeled. If more information regarding the concrete design and site conditions were available, a better estimate of degradation rate could be determined. Clifton and Knab (1989) formulated different parameters and concluded that concretes with low permeabilities are most likely to achieve service lives of around 500 years. From the literature gathered at the time of this report, it appears that longer service lives are possible, but have not been investigated. The most significant factors from the above lists are:

- The water-to-cement ratio of the mix design is crucial for determining permeability. However, the lower the ratio, the more brittle and susceptible to cracking the concrete becomes.

- The addition of pozzolonic materials significantly reduces the effect of degradation and cracking. Other additions such as superplasticizers and water reducers will improve workability at low water-to-cement ratios. Air entraining agents will reduce the amount of fluid migration into the concrete.

- Prestressing and post-tensioning can virtually eliminate the cracks in concrete. Yet, the long-term effects of stress relaxation may eliminate the function of the prestress. Creep can also promote prestress loss. Creep is the phenomenon in which concrete flows plasticly under load.

- Shrinkage is very important in concrete performance because concrete can shrink and crack substantially if not properly cured. However, 80 percent of shrinkage occurs in the first year.

- Sulfate attack can degrade concrete significantly. Most likely, the concrete will be mixed to resist this and other chemical processes.

- Alkali-aggregate and alkali-carbonate reactions can cause the concrete to crack because of the internal development of localized expansive stresses.

- Chloride attack does not directly degrade concrete but corrodes reinforcing steel leaving less steel to resist cracks. Also, steel corrosion is an expansive reaction that may cause internal stresses, cracking the concrete even further.

Cracking resistance is directly proportional to the area of steel. The American Concrete Institute (ACI) Building Code gives a relation for crack width based on the stress in the steel and the area of reinforcement (ACI 1983). Once a crack ratio is established, relative permeability can be

determined. Walton and Seitz (1991) cite an empirical relationship for permeability resulting from cracks:

$$I_f = b^3/(12s) \qquad (6)$$

where

I_f = permeability,
b = width, and
s = crack spacing.

This relationship assumes that cracks extend through the entire concrete section. However, most cracking occurs on the tension side of the member, so this equation may have limited application.

Walton and Seitz (1991) state that the leakage rate through a well-engineered cover is about 0.5 cm/year (0.2 in./year) and go further to state that an engineered cover over the vault will only improve waste isolation performance if leakage rates can be reduced below 0.1 cm/year (0.04 in./year). As the concrete vault degrades and permeability increases, the moisture flux rate becomes dependent upon cover performance at higher leakage rates. Because the performance of the engineered cover is likely to degrade much more rapidly than the underlying concrete vault, it is unlikely that the engineered cover will contribute significantly to the long-term waste isolation performance of the storage system. If the engineered cover leakage rate is 0.5 cm/year (0.2 in./year), the cover will be insignificant. A membrane liner in the fill will reduce this cover leakage rate. In turn, the concrete leakage rate will also be reduced.

Typical hydraulic conductivity values of a vault with no cover are given in some of the literature. Walton and Seitz (1991) approximate the hydraulic conductivity at 3.2×10^{-3} to 3.2×10^{-5} cm/year (1.26×10^{-3} to 1.26×10^{-5} in./year) for a vault in good condition. A degraded vault has conductivities of 3.2×10^{-1} to 3.2×10^{-3} cm/year (1.26×10^{-1} to 1.26×10^{-3} in./year). Values of 3.2×10^{-4} and 3.2×10^{-2} cm/year (1.26×10^{-4} and 1.26×10^{-2} in./year) were chosen for this analysis to represent a vault at 100 years in good condition, and a vault at 500 years in poor condition. These preliminary values were based on the extensive research conducted by Walton and Seitz (1991) and represent a conservative approach. Site-specific values were not available due to the preliminary nature of the design. The effect of cracking was specifically excluded because Walton and Seitz (1991) indicate that concrete vaults can be designed to minimize the impact of cracks.

Given the hydraulic conductivities, it is necessary to establish the pressure head for perched water above a vault. The cover is a multi-layered composition of clay, sand, gravel, etc. designed to divert water away from the vault. After a period of time, this cover is expected to lose its effectiveness so that water will infiltrate as time goes on. Also, rainfall varies throughout the year. For the purpose of this study, an average pressure head was assumed to be 10 centimeters (4 inches) throughout the year. Under these assumptions, two leakage rates are established according to the data presented in Walton and Seitz (1991). The equation for one-dimensional flow is (Freeze and Cherry 1979):

$$q = K\Delta h/\Delta l \qquad (7)$$

where

q = leakage (specific discharge),
K = hydraulic conductivity,
Δh = difference in head between top and bottom surfaces of vault ceiling, and
Δl = thickness of vault ceiling.

The thickness of the vault ceiling is not known, so the $\Delta h/\Delta l$ term was set to equal the 10-centimeter (4-inch) assumed head. This is a conservative assumption, since the ceiling thickness would probably range from 5 to 50 centimeters (2 to 20 inches). The calculated rates are:

- At time = 100 years, leakage = 0.0032 cm/year (0.0013 in./year)
- At time = 500 years, leakage = 0.32 cm/year (0.13 in./year)

These rates were then used to estimate the preliminary time-leakage graph for the infiltration rate through a concrete vault without a cap, as shown in Figure I.6-4.

Because the vault designs have not yet been initiated, information about a capping membrane and its life expectancy were unavailable. Therefore, the following assumptions were made:

1. The membrane will exist for 500 years before there is 100 percent flow through it.
2. Flaws are assumed to progress linearly with time and are expressed as (area of flaw)/(total area).

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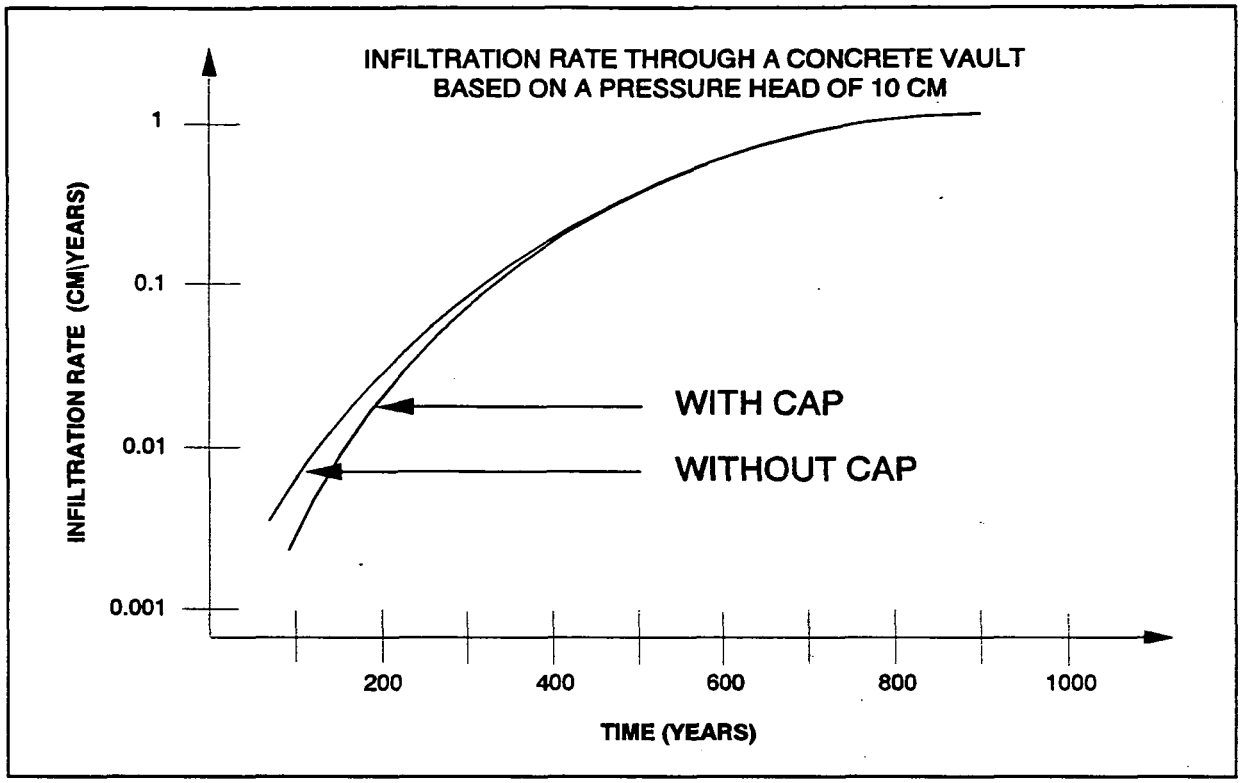

FIGURE I.6-4

INFILTRATION RATES THROUGH THE VAULT SYSTEM

Walton and Seitz (1991) state that during construction and through time, the membranes will develop punctures, tears, leaks at seams, or flaws that allow the percolation of fluids. The following relation was developed based on their stated assumptions and judgement:

Time (years)	Ratio of Area of Flaws to Total Area	Ratio of Flow with Membrane to Flow without Membrane
0.00	0.00	0.00
100	0.20	0.60
200	0.40	0.90
300	0.60	0.96
400	0.80	0.99
500	1.00	1.00

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Based on the assumptions, the membrane is only effective during the first few hundred years of service. The preliminary time-leakage graph for infiltration with a cap based on this information is also shown in Figure I.6-4. Note the minor difference between the flow with the membrane and without the membrane. Because of the uncertainties involved in this analysis, the Operable Unit 3 vault infiltration rate was set at a constant 1.3 cm/year (0.5 in./year).

I.6.1.4 Vadose Zone Modeling

The source terms that are defined for the groundwater pathway in Section I.6.1.3 were used as input to the vadose zone model. The development of this model is described in the next section, followed by the model results.

I.6.1.4.1 Vadose Zone Model Development

A vadose zone is defined as the unsaturated zone above the groundwater table of the aquifer. In this zone, the interstices are occupied partially by water and partially by air. At the FEMP, two distinct deposits, or layers, have been identified that constitute the vadose zone. The uppermost layer (Layer 1) consists of dense, fine-grained glacial overburden that overlie the unsaturated outwash deposits. Within these till deposits, there are numerous water-bearing zones that have limited interconnection, the majority of which are of glaciofluvial origin and consist of small beds of highly sorted sands and gravels. These beds are probably the result of small meltwater streams that occurred along the ice margin and within the glacier itself. Movement of water and contaminants within these units may be limited due to their limited extent and interconnection. Overlying the Great Miami Aquifer at the FEMP are approximately 4.6 to 11 meters (15 to 35 feet) of unsaturated sand and gravel outwash deposits (Layer 2). These deposits are assumed to have the same hydraulic characteristics as the underlying saturated material since the deposits are essentially the same. Additional information on hydrogeology FEMP is in the SWCR.

Vadose zone modeling was performed to estimate contaminant loading rates to the Great Miami Aquifer from a given source as a function of time. The overburden has a capacity for immobilization and retardation of contaminants due to adsorption, precipitation, biodegradation, and radioactive decay. This capacity to prevent or slow the movement of contaminants to the aquifer has been evaluated with respect to future risk.

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A one-dimensional analytical model was selected to evaluate the flow in the vadose zone, ODAST, Version 2 (Javendel et al. 1984). The model was previously selected for use, as discussed in the SWCR, based upon the following factors:

- Analytical methods are the most efficient alternative when data necessary for the characterization of the system is sparse and uncertain.
- These methods are consistent with approaches used for similar radionuclide assessment models such as the flow portions of PRESTO (EPA 1987c and other site studies).
- The basis of the solution is well documented and the software code has been extensively verified.

ODAST was used for determining the fate and transport of the constituents in the unsaturated zone that were retained for study after the screening process of Section I.6.1.2. Based on the solution originally developed by Ogata and Banks (1961), ODAST 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. It 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. ODAST has been extensively verified against the model STRIP1B (Batu 1989).

The current use of the ODAST analytical model is being re-evaluated by the Operable Unit 5 staff. Future editions of the CRARE may include the use of a 2 or 3-dimensional numerical model for the vadose zone. The reason for this potential change would be the inability of analytical models to adequately simulate the complex flow patterns in the vadose zone.

The input flow rates and COC concentrations with time to the ODAST model are the source terms described in Section I.6.1.3 for Operable Units 3 and 5, plus the source terms described for the PRAs in the Operable Unit 1, 2, and 4 FS documents. Two other sets of source terms, from Paddys Run and the storm sewer outfall ditch (SSOD), were input directly to the SWIFT III groundwater model. These are described in Section I.6.1.5. The vadose zone is thinner and consists primarily of coarse material in the areas of surface water recharge to groundwater; therefore, it is reasonable to assume that the contaminant retardation would be minimal.

A utility code, SWIFLOAD, was written to run ODAST on cell-by-cell or specified-area input. Input files for the ODAST modeling were developed to represent the same 38-by-38 meter (125-by-125-foot) grid cell layout of the SWIFT III model. This allowed the ODAST output to be used as input directly to SWIFT without additional manipulation.

The thickness of each soil layer was gridded and provided to SWIFLOAD on a cell-by-cell basis. The conductivities used for Layers 1 and 2 were 0.008 and 13.7 m/day (0.0264 and 45 ft/day), respectively. The Layer 1 conductivity was estimated by log averaging the 1000 series-well slug test results (as of February 1993) and dividing by 20 to account for the horizontal-to-vertical ratio. Because the FEMP site has two distinct layers in the vadose zone, ODAST was run for each to calculate the normalized concentration at the bottom of each layer for each time step. In general, dispersion through the lower layer did not come into effect until the constituent reached the bottom of the adjacent upper layer.

ODAST requires the input of a retardation factor (R_f), which is derived from the K_d by the equation:

$$R_f = 1 + K_d \rho_b/\theta \qquad (8)$$

where

R_f = retardation factor
ρ_b = bulk density
θ = moisture content
K_d = soil partitioning coefficient

The SWCR estimates that the bulk densities of Layers 1 and 2 are 1.78 and 1.60 g/cc, respectively, and the moisture contents are 28 and 14 percent, respectively. The Operable Unit 5 staff has re-evaluated the K_d values for uranium that were originally provided in the SWCR. Their analysis is presented in *Groundwater Model Improvement Task Objectives and Technical Approach, Zonation and Values of Geochemical Parameters*, which is included in Attachment I.V. Operable Units 1, 2, and 4 have also developed some site-specific K_d and R_f values. Most of the K_d values for COCs other than uranium remained the same as those listed in the SWCR.

Table I.6-4 lists the specific K_d and R_f values for the groundwater pathway COCs, and also the radioactive decay constants. A biodegradation coefficient is not available for the only organic compound among these COCs, Aroclor-1221. The decay constants are also taken from the SWCR.

Uranium is present in the perched water within the vadose zone beneath the central portion of the FEMP, and a portion of this perched water will be remediated. Therefore, a level of uranium will remain in the perched water at the end of FEMP remediation. ODAST, however, cannot start with U-238 already in transit through the soil column being modeled. Therefore, to approximate the residual contamination caused by the perched water source after its remediation, ODAST modeled the perched water areas starting 40 years before the zero time of the start of the SWIFT model.

The 40-year period was selected for perched water as an approximation of the time for the completion of remediation. This provided some contamination in the vadose zone as represented in ODAST at the conclusion of remediation. The ODAST input concentrations for these areas were provided by first averaging the 1000-series well sample results. However, remediation is planned to be conducted to reduce the higher COC concentrations in the perched water, although not necessarily to drinking water standards. Therefore, to approximate the effect of this remediation, an arbitrary standard of 100 times the drinking water standard was selected as the maximum perched water concentration after remediation. Any of the averaged results that exceeded this standard were then reduced to it to approximate the effects of the perched water remediation. At the zero time, the perched water inflows were stopped in the ODAST runs, and the source terms (Section I.6.1.3) were initiated.

Section I.5.0 describes how exposure scenarios have been developed for this CRARE. ODAST runs were completed for each COC, to simulate the Current Land Use and both Future Land Use scenarios. The Current Land Use scenario included only a 70-year period and assumed that leachate from the vaults were captured and not allowed to infiltrate the vadose zone. The Future Land Use scenarios included 1000 years and assumed that all source areas were releasing COCs as described in this section.

TABLE I.6-4
VADOSE ZONE MODEL PARAMETERS

COC	Layer 1 Kd (ml/g)	Layer 1 Rf (unitless)	Layer 2 Kd (ml/g)	Layer 2 Rf (unitless)	Radioactive Decay Constant (day^{-1})
U-238					
OU1 Area	240	1257	1.78	11.75	4.25×10^{-13}
OU4 Area	12	63.82	1.78	11.75	4.25×10^{-13}
OU2					
South Field and Inactive Fly Ash Pile South Field	200	1001	1.78	36.6 to 63.29	4.25×10^{-13}
Site-Wide Soils					
Plants 2/3, 6 and 9	15	79.53	1.78	11.75	4.25×10^{-13}
Main Plant	222	1163	1.78	11.75	4.25×10^{-13}
Remainder of FEMP	222	1163	1.78	11.75	4.25×10^{-13}
Tc-99					
OU1 Area	0.12	1.75	0.07	1.80	8.92×10^{-9}
OU2 Areas	0.12	1.54	0.17	3.00	8.92×10^{-9}
Site-Wide Soils	0.12	1.75	0.07	1.80	8.92×10^{-9}
Np-237	55	289	2.69	31.8	8.87×10^{-10}
Cadmium					NA
OU1 Area	500	2618	12	74.85	
Site-Wide Soils	500	3180	12	138	
Antimony					NA
OU1 Area	250	1310	45	278	
Site-Wide Soils	250	1590	45	515	
Aroclor-1221	235	1500	101	1160	NA

NA = Not Applicable. COC does not radioactively decay.
SOURCES: SWCR (DOE 1993e)
OU1 FS Report (DOE 1993g)
OU2 FS Report (DOE 1994b)
OU4 FS Report (DOE 1993h)
Groundwater Model Improvement Task Objectives and Technical Approach Zonation and Values of Geochemical Parameters (Attachment I.V)

I.6.1.4.2 Vadose Zone Model Results

Loading rates to the Great Miami Aquifer were estimated for each COC for the SWIFT cells at each source area using ODAST. Attachment I.II provides a listing of the mass loading rates for U-238 to the Great Miami Aquifer for 1000 years from each waste area. Table I.6-5 provides summaries of the total mass loading from the vadose zone modeling for the Current and Future Land Use scenarios. In the table, the values in the Mass Transport to Groundwater columns are generally less than the mass of the COC removed from the source area, because some of the COC remains in transit through the vadose zone at the end of the specified time period. The time at which the remaining mobile mass becomes zero is also provided. A value of either 1 gram or 1 billionth (10^{-9}) of the Initial Mobile Mass for each area (whichever is smaller) is assumed to be equivalent to a zero mass value.

Figure I.6-5 depicts the source depletion rate of U-238 from the soils. In SWCR studies, loading rates were found to be sensitive to changes in the leach rate of the waste, thickness of the vadose zone, dispersion coefficient, interstitial water velocity, retardation factor, radioactive decay factor, biodegradation, and depletion time of the source. The loading rates were used as input for SWIFT III to model the groundwater movement and solute transport in the Great Miami Aquifer. Section I.10.3 analyzes the uncertainties related to modeling the groundwater pathway.

The loading rates of a constituent traveling to the aquifer from a given source vary over time. Typically, loading rates increase sharply during an initial time period and then stabilize or decrease, depending on the depletion time of the source. For longer depletion times, the source remains active longer during the simulation, and may approach a steady-state condition within the 1000-year simulation time of the Future Land Use scenarios.

I.6.1.5 Surface Water Modeling

Surface water modeling was used for two purposes: to define source terms for the SWIFT III groundwater model and to estimate contaminant concentrations in surface water bodies as an exposure medium. Potential exposures for a future recreational use of surface water include dermal contact and incidental ingestion.

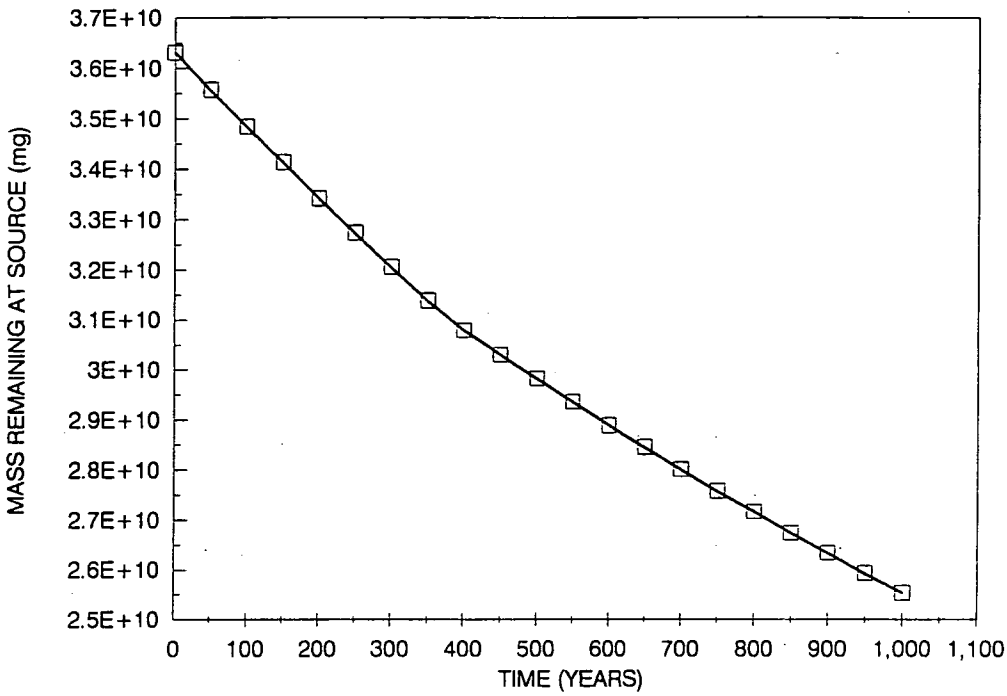

FIGURE I.6-5

DEPLETION RATE OF U-238 FROM THE RESIDUAL SOILS

I.6.1.5.1 Surface Water Model Development

Surface soil was estimated to be the only source of surface water contamination for this CRARE. The Operable Unit 3 vaults were not included as sources because they have been designed with floors recessed below ground level and leachate collection systems located beneath the floors. Leachate that contacts the waste will collect in these subsurface systems rather than exit to surface runoff. At the end of any maintenance period, the subsurface collection systems are expected to develop leaks such that all leachate will escape downward to groundwater. The capped areas of Operable Units 1 and 2 are expected to maintain the integrity of their caps so that no wastes are exposed to surface runoff.

TABLE I.6-5
SUMMARY OF VADOSE ZONE MODELING RESULTS

Source Area	Initial Mobile Mass (mg)	Current Land Use Scenario Mass Transport to Groundwater After 70 Years (mg)	Future Land Use Scenarios Mass Transport to Groundwater After 1000 Years (mg)	Future Land Use Scenario Remaining Mobile Mass At 1000 Years (mg)	Time at Which Remaining Mobile Mass Becomes Zero (Years)[a]
U-238					
Eastern Vaults	2.635×10^{12}	0.000×10^{0}	0.000×10^{0}	2.635×10^{12}	4.665×10^{9}
OU4 Contaminated Soils	1.083×10^{7}	0.000×10^{0}	1.030×10^{7}	0.000×10^{0}	7.0×10^{1}
OU1 Contaminated Soils	2.876×10^{10}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	5.686×10^{4} to 4.073×10^{5} [b]
OU2					
South Field & Inactive Flyash Pile	1.262×10^{10}	1.061×10^{-3}	1.306×10^{8}	1.027×10^{10}	7.0×10^{1} to 3.186×10^{5} [c]
Perched Water	3.946×10^{7}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	7.0×10^{1}
Site-Wide Soils					
Main Plant Area					
Plant 2/3	9.325×10^{8}	0.000×10^{0}	0.000×10^{0}	7.161×10^{8}	7.856×10^{4}
Plant 6	4.662×10^{8}	0.000×10^{0}	0.000×10^{0}	3.580×10^{8}	7.856×10^{4}
Plant 9	4.662×10^{8}	0.000×10^{0}	0.000×10^{0}	3.580×10^{8}	7.856×10^{4}
Remainder	4.403×10^{9}	0.000×10^{0}	0.000×10^{0}	2.516×10^{9}	3.706×10^{4}
East Plant Area	4.080×10^{8}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	3.788×10^{2}
West Plant Area	8.742×10^{8}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	3.788×10^{2}
Perched Water	6.968×10^{6}	2.105×10^{3}	1.741×10^{5}	0.000×10^{0}	7.0×10^{1}
Tc-99					
Eastern Vaults	2.615×10^{4}	7.849×10^{2}	2.599×10^{4}	0.000×10^{0}	7.0×10^{1}
OU1 Contaminated Soils	8.220×10^{4}	3.804×10^{4}	8.218×10^{4}	0.000×10^{0}	7.0×10^{1}
OU2 Solid-Waste Landfill	1.524×10^{7}	0.000×10^{0}	2.052×10^{2}	1.524×10^{7}	6.330×10^{6}
Site-Wide Soils					
Main Plant Area	1.818×10^{5}	1.081×10^{5}	1.818×10^{5}	0.000×10^{0}	7.0×10^{1}
East Plant Area	2.383×10^{3}	1.166×10^{3}	2.383×10^{3}	0.000×10^{0}	7.0×10^{1}
West Plant Area	5.107×10^{3}	2.935×10^{3}	5.107×10^{3}	0.000×10^{0}	7.0×10^{1}

See footnotes at end of table.

TABLE I.6-5
(Continued)

Source Area	Initial Mobile Mass (mg)	Current Land Use Scenario Mass Transport to Groundwater After 70 Years (mg)	Future Land Use Scenarios Mass Transport to Groundwater After 1000 Years (mg)	Future Land Use Scenario Remaining Mobile Mass At 1000 Years (mg)	Time at Which Remaining Mobile Mass Becomes Zero (Years)[a]
Np-237					
OU1 Contaminated Soils	1.140×10^5	0.000×10^0	0.000×10^0	3.837×10^4	1.299×10^4 to 1.069×10^5 [b]
Site-Wide Soils					
Plant 2/3	2.248×10^5	0.000×10^0	0.000×10^0	1.766×10^4	1.085×10^3
Plant 6	1.241×10^5	0.000×10^0	0.000×10^0	7.246×10^2	1.006×10^3
Cadmium					
Eastern Vaults	8.895×10^8	0.000×10^0	0.000×10^0	0.000×10^0	7.0×10^1
OU1 Contaminated Soils	9.319×10^8	0.000×10^0	0.000×10^0	8.100×10^8	1.181×10^5 to 9.735×10^5 [b]
Site-Wide Soils					
Plant 2/3	1.835×10^8	0.000×10^0	0.000×10^0	1.800×10^8	5.317×10^4
Plant 9	1.435×10^8	0.000×10^0	0.000×10^0	1.408×10^8	5.317×10^4
Remainder	4.176×10^9	0.000×10^0	0.000×10^0	3.460×10^8	1.102×10^5
Antimony					
Eastern Vaults	4.618×10^9	0.000×10^0	0.000×10^0	0.000×10^0	8.829×10^2
OU1 Contaminated Soils	4.371×10^9	0.000×10^0	0.000×10^0	3.316×10^9	5.906×10^4 to 4.865×10^5 [b]
Site-Wide Soils					
Plant 6	3.215×10^8	0.000×10^0	0.000×10^0	3.126×10^8	7.374×10^5
Plant 9	7.985×10^7	0.000×10^0	0.000×10^0	7.764×10^7	7.374×10^5
Remainder	8.539×10^9	0.000×10^0	0.000×10^0	6.445×10^9	7.371×10^4

See footnotes at end of table.

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TABLE I.6-5
(Continued)

Source Area	Initial Mobile Mass (mg)	Current Land Use Scenario Mass Transport to Groundwater After 70 Years (mg)	Future Land Use Scenarios Mass Transport to Groundwater After 1000 Years (mg)	Future Land Use Scenario Remaining Mobile Mass At 1000 Years (mg)	Time at Which Remaining Mobile Mass Becomes Zero (Years)[a]
Aroclor-1221					
Eastern Vaults	1.322×10^{7}	0.000×10^{0}	0.000×10^{0}	0.000×10^{0}	7.0×10^{1}
Site-Wide Soils					
Plant 2/3	2.200×10^{8}	0.000×10^{0}	0.000×10^{0}	2.135×10^{8}	7.803×10^{5}
Plant 9	1.163×10^{7}	0.000×10^{0}	0.000×10^{0}	1.129×10^{7}	7.803×10^{5}
Remainder	2.701×10^{8}	0.000×10^{0}	0.000×10^{0}	2.004×10^{8}	7.801×10^{4}

[a]The time at which the mobile mass becomes negligibly small is defined as the smaller of 1 gram or 10^{-9} times the original mass.
[b]The values given are for surface soil without cover and surface soil with cover, respectively.
[c]The range of values given corresponds to the minimum and maximum times for depletion for the 38 different grid squares individually modeled in this area.

Only the COCs that passed the screening of Section I.6.1.2 were evaluated for surface water transport. The same soil retention effects (characterized by R_f) that delay the release of COCs from the vadose zone soils also delay the release of the COCs from surface soils to surface water. Additional COCs may be evaluated for surface water transport in future versions of the CRARE. Only U-238, Tc-99, Np-237, and antimony were modeled for surface water transport. Aroclor-1221, and cadmium were screened out because they are not Constituents of Potential Concern in surface water (Baseline and Future conditions) in the Operable Unit 5 RI report.

The SWCR conducted surface water modeling for a wide range of COCs and reported that, with the exception of uranium, concentrations in the receiving streams were predicted to be generally very low. The SWCR estimates that future surface water concentrations in the Great Miami River are below 1 pCi/l for all radionuclides except the uranium isotopes. Activity concentrations for U-234, U-235/236, and U-238 are estimated at 24, 1.3, and 28 pCi/l, respectively. Modeled concentrations for organic compounds range from 4.9×10^{-11} to 1.1×10^{-4} mg/l and are all below usual analytical detection levels. Modeled concentrations for inorganics except uranium range from 3.8×10^{-7} to 1.4×10^{-5} mg/l, also below analytical detection levels. The SWCR also includes risk assessments for surface water concentrations.

The FEMP is located on a gently sloping plateau bounded on the north and east sides by distinct drainage divides and on a third side by Paddys Run, a small intermittent stream. A topographic map of the FEMP is shown in Figure I.1-3 (Section I.1.3.2). Surface water transport of contaminants at the FEMP occurs intermittently, principally during rainstorms. Free-flowing surface water on the FEMP eventually flows down one of three drainage features to the Great Miami River. Two of these are Paddys Run and the SSOD, the primary drainage features on the property. The third, a small watershed in the northeast corner of the FEMP which drains to the east, was eliminated from further study because it contains no discernable sources.

Several areas are currently served by a system of engineered drainage features, such as ditches and runoff collection basins, as described in further detail by WEMCO (1991). The two most significant areas drained by this system are the production and the waste storage areas. Runoff from the Production Area, plus the incinerator area was assumed to continue to flow into the SSOD after FEMP remediation. Runoff from the silo area, waste storage area, and South Field

was assumed to continue to enter Paddys Run. To be conservative, the assumption has been made that stormwater runoff patterns in the future will be similar to present conditions. The same assumption was used for surface water runoff modeling in the SWCR.

Modeling of surface water flow and transport was modified from the Operable Unit 4 CRARE approach. This approach is described in the *Surface Water Flow and Infiltration Model Summary Report* (SWF&IM report) and is briefly described here. The primary purpose of the SWF&IM report is to provide information concerning the hydrology and hydraulics of the Paddys Run drainage basin needed to conduct modeling of future containment transport in the surface water at the FEMP. The technical approach used for the fate and transport modeling is also described in the report.

The Surface Water Flow and Infiltration Model (SWF&IM) was applied first in the process of modeling surface water flow and transport. It is a subset of the larger, overall approach to this modeling, and provides results to be used in contaminant transport calculations. In general, the SWF&IM is only concerned with the movement of water and does not consider contaminant transport. The SWF&IM consists of the following components. The rainfall and runoff are simulated with the HEC-1 modeling code (U.S. Army Corps of Engineers 1990). Rating curves for cross-sections along Paddys Run and the SSOD are generated using Manning's equation (Henderson 1966). Manning's equation is applied along Paddys Run and the SSOD to determine the elevation of water in the stream (stage) at each cross section for a given flow rate (discharge). This relationship between stage and discharge at a cross section of a stream is called a rating curve. Drainage basins at the FEMP and the cross-section locations are shown in Figure I.6-6.

To calculate infiltration from surface water to the Great Miami Aquifer, the computer code VS2DT (Healy 1990) was applied at each cross section. A time-varying depth of water was input into the VS2DT program for the infiltration calculations to simulate the fluctuation of flow depths in the streams during a storm. The stream water depth was based on the runoff hydrographs from HEC-1 combined with the rating curves developed with Manning's equation. The output from VS2DT provided the infiltration volumes to the Great Miami Aquifer along the length of Paddys Run and the SSOD. The runoff hydrographs and infiltration information were then used in calculating contaminant concentrations and loadings.

The calculations of the contaminant concentrations in the surface water bodies required estimates of the surface water flow rates and volumes, and estimates of the amount of contaminants being transported from the source soil with the runoff. The contaminant can move with the runoff in two phases: absorbed to sediment eroded from the land surface or dissolved in the runoff itself. The amount of contaminant absorbed to the sediment and the amount dissolved in the surface water runoff were estimated with partitioning equations presented in the Superfund Exposure Assessment Manual (EPA 1988). The amount of sediment generated from a single storm was estimated with the Modified Universal Soil Loss Equation (MUSLE), which is also presented in the manual.

The 1000-year duration of the Future Land Use scenario could make depletion of the source soil an important consideration in determining surface water concentrations and the contaminant loadings to the Great Miami Aquifer. The annual soil depletion was calculated in the Operable Unit 5 RI using the Universal Soil Loss Equation (USLE) presented in the Superfund Exposure Assessment Manual (EPA 1988). The preliminary results of the USLE calculations indicated that the source soil would not erode completely during the 1000-year time frame. Because the contaminated source soils would still be present during the time frame of the study, the depletion of the source soil by erosion was not significant and was not used in the procedure. Therefore, the loadings were assumed to be constant over the 1000 years.

The contaminant concentrations in Paddys Run and the SSOD were calculated by combining runoff from contaminated subbasins with runoff from uncontaminated subbasins. This mixing is based on dilution factors between the subbasin flow and the receiving stream (Paddys Run or the SSOD). These calculations were performed using the dilution factors and dissolved contaminant masses from the partitioning equations.

To be conservative, the procedure for estimating concentrations in the surface water assumed that no mass of contaminant is lost to infiltration through the streambeds. This assumption would represent a worst-case scenario for concentrations in the surface water. If a storm occurred when the streambeds are saturated (i.e., immediately following a previous storm or in the spring when storms occur frequently), little or no dissolved contaminant would infiltrate through the

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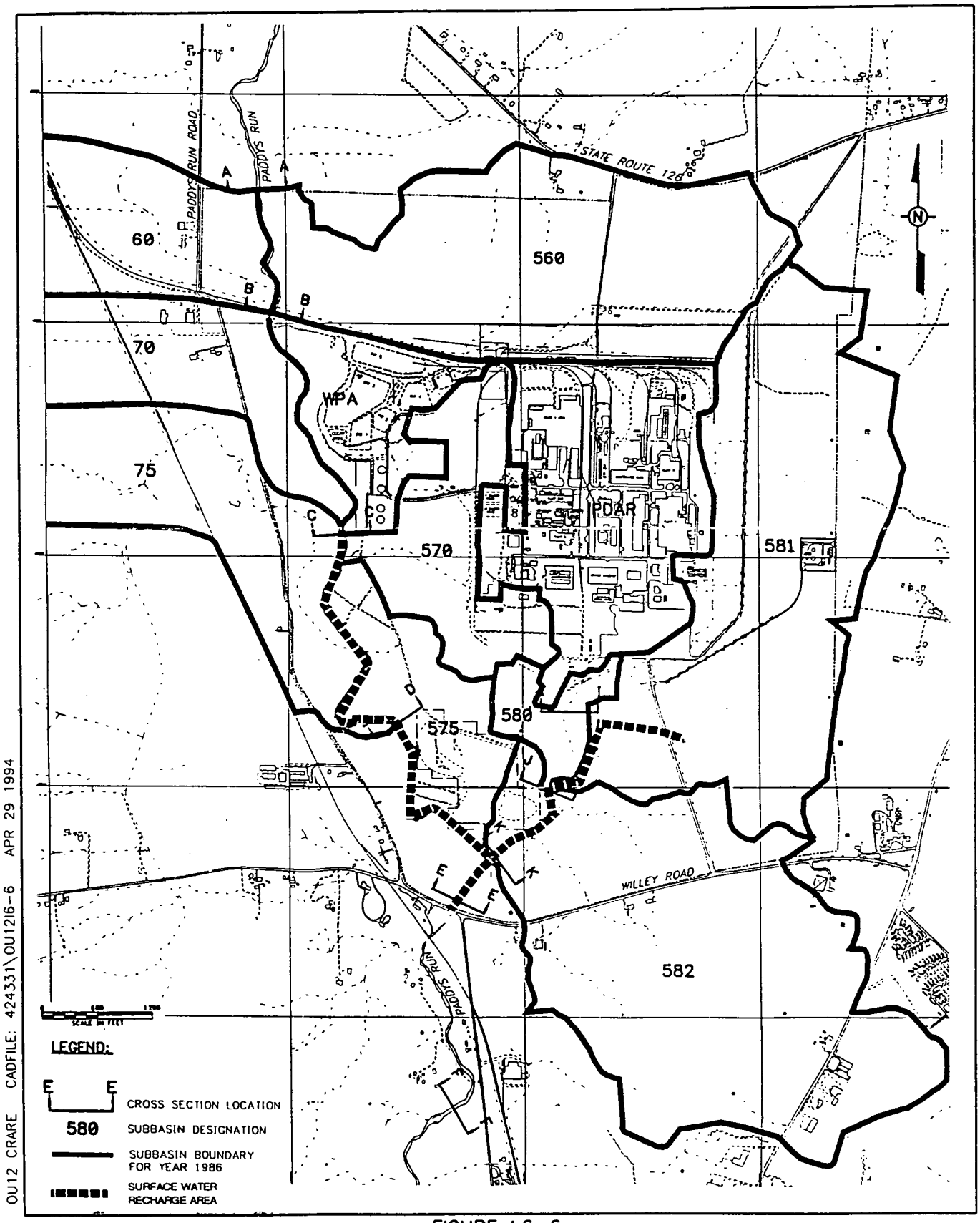

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FIGURE 1.6-6
PADDYS RUN DRAINAGE SUBBASINS
FOR HEC-1 MODEL CONTAMINATION CALCULATIONS

streambeds. If the storm occurred at any other time, more contaminant would likely infiltrate, leaving less contaminant for the concentration in the surface waters.

Two contaminant loading rates were calculated to simulate the loading to the Great Miami Aquifer for the entire year: the loading due to a single representative storm, and an average loading for six months of the year. The assumption of loading only for six months per year is based on the concept that flow in Paddys Run, and hence the contaminant loading, does not occur continually throughout the year since Paddys Run and its tributaries are often dry for extended periods. The single representative storm loading rate was used to simulate the relatively few number of large storms per year that create substantial amounts of runoff. The average loading was used to represent the common storms that occur during the year.

To be conservative, the procedure for estimating contaminant loadings to the groundwater due to infiltration through the streambeds of Paddys Run and the SSOD was based on infiltration calculations that assume the streambeds are initially unsaturated. This establishes conservatively high rates of infiltration and contaminant transport through the streambed to the Great Miami Aquifer.

Stormwater management is not included as an ongoing activity for site-wide soils in the remedial alternatives (Section I.2.2) after FEMP remediation. However, several stormwater retention structures are assumed to remain after remediation, as discussed in Section I.2.3. Section I.5.0 describes how exposure scenarios have been developed for this CRARE. Model runs were completed for each COC to simulate the Current Land Use and both Future Land Use scenarios. The first run covered a 70-year period and assumed that stormwater discharge to the SSOD from the Production Area was first captured in stormwater retention basins and then treated to remove the COCs. The second run, which addressed both Future Land Use scenarios, covered 1000 years and assumed that there was no capture and treatment of stormwater.

I.6.1.5.2 Surface Water Model Results

COC concentrations in surface water predicted to occur under the Current Land Use and Future Land Use scenarios are listed in Table I.6-6. The surface water modeling results as a source to groundwater are summarized in Table I.6-7. The locations of the surface water recharge to

TABLE I.6-6

ESTIMATED COC CONCENTRATIONS (μg/l) IN SURFACE WATER

	Current Land Use			Future Land Use		
COC	C[a]	D[a]	E[a]	C[a]	D[a]	E[a]
U-238	7.38	2.24	4.73	7.52	3.31	35.8
Tc-99	4.84×10^{-3}	1.59×10^{-3}	1.98×10^{-2}	3.57×10^{-3}	1.71×10^{-3}	5.16×10^{-2}
Np-237	0.0	0.0	5.07×10^{-5}	0.0	0.0	1.81×10^{-4}
Antimony	4.07×10^{-1}	2.01×10^{-1}	3.90×10^{-2}	5.51×10^{-1}	2.75×10^{-1}	7.64×10^{-2}

[a] Letters designate cross-section locations shown on Figure I.6-6.

TABLE I.6-7

ESTIMATED COC TRANSPORT (g/year) FROM SURFACE WATER TO GROUNDWATER

	Current Land Use		Future Land Use	
COC	Paddys Run	SSOD	Paddys Run	SSOD
U-238	1.60×10^{3}	2.82×10^{3}	2.51×10^{3}	2.56×10^{4}
Tc-99	4.78×10^{0}	1.38×10^{1}	5.52×10^{0}	4.50×10^{1}
Np-237	9.97×10^{-4}	3.76×10^{-2}	2.97×10^{-3}	1.38×10^{-1}
Antimony	4.23×10^{2}	1.10×10^{-1}	5.23×10^{2}	5.21×10^{-1}

groundwater are shown in Figure I.6-6. Concentrations and loading rates for all COCs were assumed to be constant over the full 70- or 1000-year duration of each scenario.

I.6.1.6 Aquifer Modeling

This section describes the prior development of the SWIFT III groundwater model as a standard approach for the FEMP site. The specific use of the model for this CRARE is also described, as are the modeling results.

I.6.1.6.1 Aquifer Model Development

CRARE groundwater modeling was performed with the previously-calibrated SWIFT groundwater flow model for the FEMP. This model uses the SWIFT III code, Version 2.52, compiled for nearly optimized performance. The SWIFT III model was previously calibrated using groundwater elevations obtained during the April 1986 monitoring period.

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The site-wide groundwater modeling program was initiated to define groundwater transport in and around the FEMP. The selection, verification, calibration, and results of groundwater modeling are presented in two reports (IT 1990a and ASI/IT 1990a). SWIFT III is a finite-difference computer model of groundwater flow and solute transport. A detailed presentation of the model, its development, and the baseline input data was issued as part of the overall modeling report prepared under the RI/FS (ASI/IT 1990a). Only the most pertinent information is presented here. A comprehensive verification study of the SWIFT III code has also been completed and a report issued (IT 1990a).

More recent modifications to the SWIFT III model are described in the following reports:

- Groundwater Modeling Report - Summary of Model Development (DOE 1993a)
- Groundwater Model Evaluation Report and Improvement Plan (DOE 1993b)
- Glacial Overburden/Upper Great Miami Aquifer System Model Report (DOE 1994a)
- Groundwater Modeling Report - Summary of Model Improvement (DOE 1994b).

Improvements made to the SWIFT model include: (1) increasing the vertical resolution, i.e., adding layers, (2) recalibrating of the flow and transport portions of the model based on the results of the South Plume Pump Test Study and Kriging analysis, respectively, and (3) incorporating a larger model area to the south and east to include the Great Miami River and the collector wells of the Southern Ohio Water Company (SOWC).

The regional SWIFT model covers an area of 74.3 km^2 (28.7 mi^2), including the FEMP, the SOWC collector wells, and a portion of the Great Miami River. The regional model's grid spacing varies between 76 and 610 meters (250 and 2000 feet), and has the closest grid spacing in the area of the SOWC collector wells. It was calibrated against field data using a steady-state flow condition, and calibration results were incorporated into the SWIFT local area model.

The local model covers a smaller area than the regional model and uses a tighter grid spacing, with grid cells 38 meters (125 feet) on a side. The grid size was selected based on the need to simulate a dispersivity of 30 meters (100 feet) longitudinally, which was the preferred value, based

on the solute transport calibration for uranium and also the literature review (IT 1990a). Using this dispersivity value, the grid size was selected to accommodate dispersivity values as low as 19 meters (62.5 feet), or half the distance of the local grid area of 38 meters (125 feet). Dispersivity is a constant value related to aquifer characteristics and not the solute being modeled. A smaller grid area was originally established to include the existing uranium plume. An expanded grid area is now in use that covers 112 by 120 cells, as shown on Figure I.6-2. The new grid was developed to expand the solute transport coverage for all of the RI/FS studies. The relationship between the local and regional SWIFT models was established by imposing the steady-state flow field predicted by the regional model onto the local solute transport model.

The regional and local models each contain six layers. These model layers were designed to coincide with the depth of Type 2 (2000-series), Type 3 (3000-series), and Type 4 (4000-series) monitoring wells, the clay interbed, and the top of bedrock contours. In regions where the clay interbed is not present, the middle layer has the same characteristics as the two upper layers. The layers extend laterally into bedrock at the edges of the buried valley that contains the aquifer. The number of aquifer cells in each layer was decreased with depth in the aquifer to simulate the narrowing bedrock valley. This was done using bedrock topography maps of the region and simulated the U-shaped buried valley that contains the Great Miami Aquifer.

The pumping wells in the area are spanned by both the regional and local models. These include (in both models) a FEMP production well, three industrial wells south of the FEMP, and two large-capacity collector wells owned by the SOWC and located by the Great Miami River. The FEMP well was assumed to be shut down after the completion of remediation. Pumping from each of the industrial and collector wells was assigned to the proper cell and layer in the model.

The SWIFT groundwater flow model was previously calibrated by comparing hydraulic heads calculated by the model against heads measured in numerous monitoring wells throughout the FEMP and surrounding areas. This calibration was performed using the regional flow model. Reasonable estimates of hydraulic conductivity and recharge were initially input into the model and then varied within an acceptable range to adjust model-computed heads into agreement with observed monitoring well heads.

Recharge rates set as a result of the regional model calibration were assigned to several different zones. In areas where the sand and gravel aquifer is overlain by glacial overburden, a recharge rate of 15 cm/year (6 in./year) was used. Regions where the Great Miami Aquifer is exposed at the surface use 36 cm/year (14 in./year), with Paddys Run channel being assigned a value of 81 cm/year (32 in./year) in the local model to simulate its increased infiltration. The calibrated recharge rate of 5 cm/year (2 in./year) for the area covered by the FEMP was used in the SWCR, and was also used in this CRARE. The loading rates of COCs with time to the SWIFT III model were determined by the ODAST vadose zone modeling or the surface water modeling.

Initial background concentrations of each compound in the aquifer were set at zero, with the exception of uranium. Because it is the most widespread COC and has the highest concentrations, uranium was assumed to be the most persistent COC during remediation. The Great Miami Aquifer groundwater in an area beneath the current sources is assumed to still contain uranium at the drinking water standard (7 pCi/l or 20.77 μg/l) at the end of FEMP remediation. This area is depicted in Figure I.6-7. K_d values for the COCs in the aquifer are presented in Table I.6-8.

TABLE I.6-8

SWIFT III Kd VALUES

COC	K_d
U-238	1.78
Tc-99	0.07
Np-237	2.69
Aroclor-1221	101
Antimony	45
Cadmium	12

I.6.1.6.2 Aquifer Model Results and Receptor Selection

Groundwater transport modeling with the SWIFT III code was first run with U-238 as the COC. U-238 was selected because the baseline modeling in the SWCR had identified it as potentially the most widespread contaminant in groundwater that represented the greatest risk. This conclusion was substantiated in the previous CRARE. Figures I.6-8 and I.6-9 present the projected COC concentration contours at 70 years after the end of remediation for the Current

Land Use and Future Land Use scenarios. Figure I.6-10 presents the concentration contours at 1000 years after the end of remediation.

The peak concentrations for U-238 occur at 70 years in both scenarios; however, the maximum value is much less in the Current Land Use scenario. For the Current Land Use scenario the 70-year peak is due to the increasing concentrations in the Operable Unit 1 area, up to the end of the 70-year period. For the Future Land Use scenario the 70-year peak is due to the surface water influx adding to the initial background concentration. Peak groundwater concentrations then slowly decline in the Future Land Use scenario for the remainder of the 1000-year period. The impact of U-238 transport from the Operable Unit 1 area can also be seen in all three figures. Results for U-234, U-235, and U-236 were developed by applying the abundance ratios of these isotopes to the U-238 results, and not by separate modeling.

Tc-99 was modeled next because it appeared to represent the second-highest potential risk in groundwater. Figures I.6-11 and I.6-12 present the projected Tc-99 concentration contours at 70 and 1000 years after the end of remediation for the Future Land Use scenarios. Site-wide Tc-99 concentrations are lower for the Current Land Use scenario, and are not shown separately. Tc-99 reaches its peak concentrations at approximately 40 years for all scenarios, and does not decline from these peaks for the remainder of the 1000 years. This is because the most significant source of contamination is surface water recharge, although impacts from the Operable Unit 1 area and site-wide soils can also be seen. When compared to the Operable Unit 4 CRARE modeling, both U-238 and Tc-99 show significant increases in groundwater concentrations that are primarily due to the assumption of constant COC loading from surface water over time.

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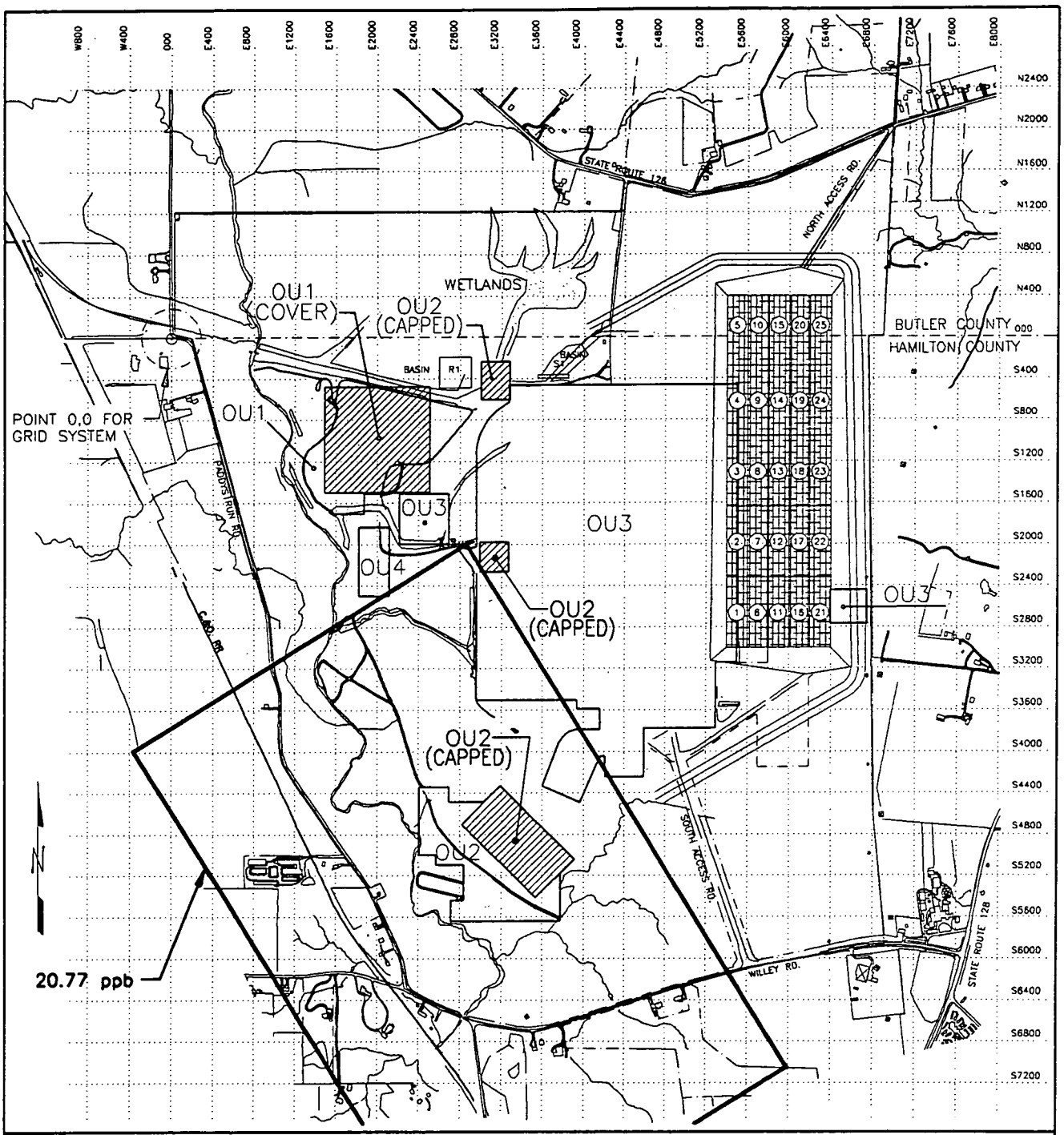

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SCALE IN FEET

: CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 20.77 ppb

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FIGURE 1.6-7
INITIAL CONCENTRATIONS OF U-238 IN AQUIFER AFTER REMEDIATION

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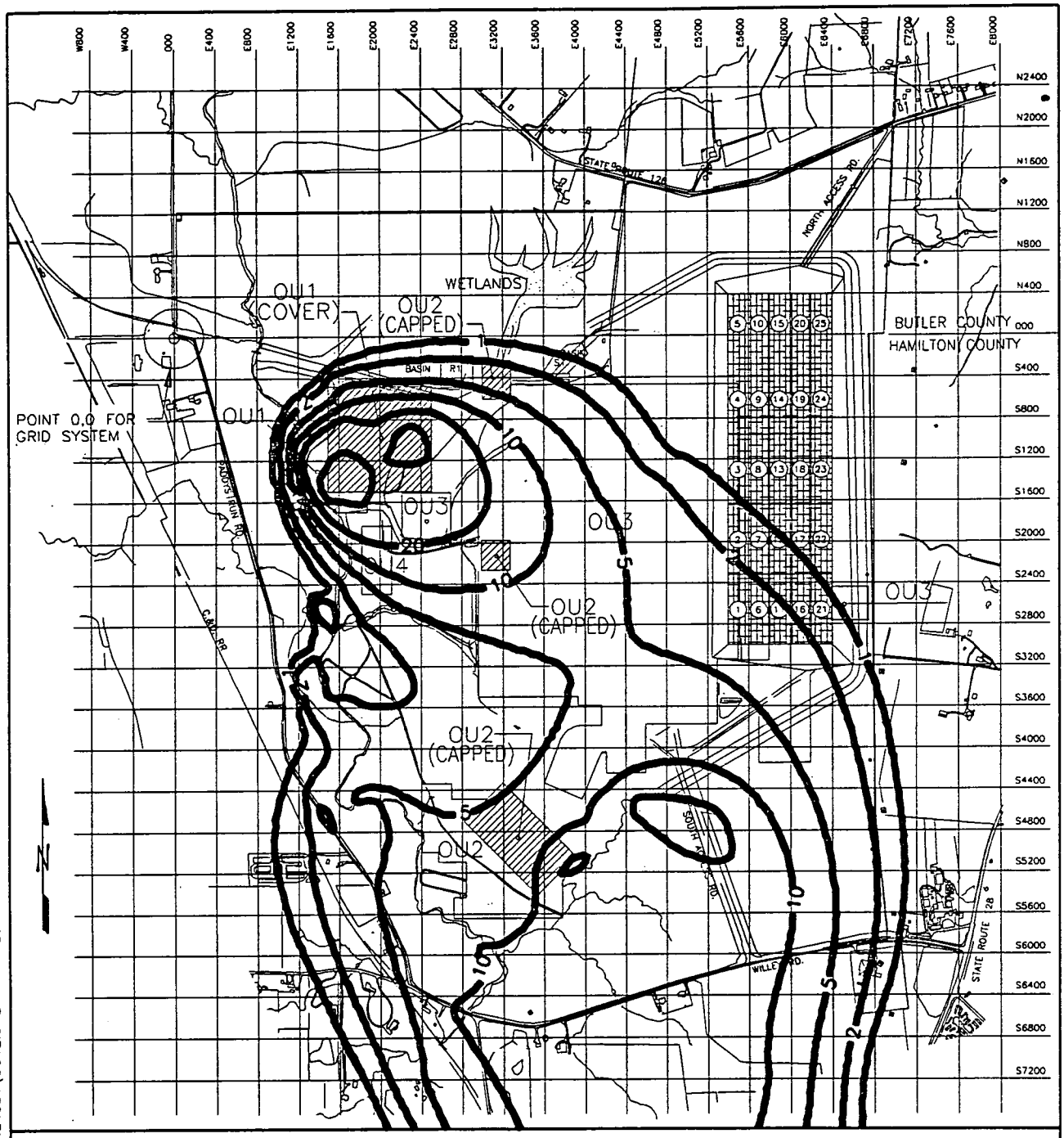

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FIGURE 1.6-8
U238 GROUNDWATER CONCENTRATIONS AT 70 YEARS
FOR CURRENT LAND USE SCENARIO

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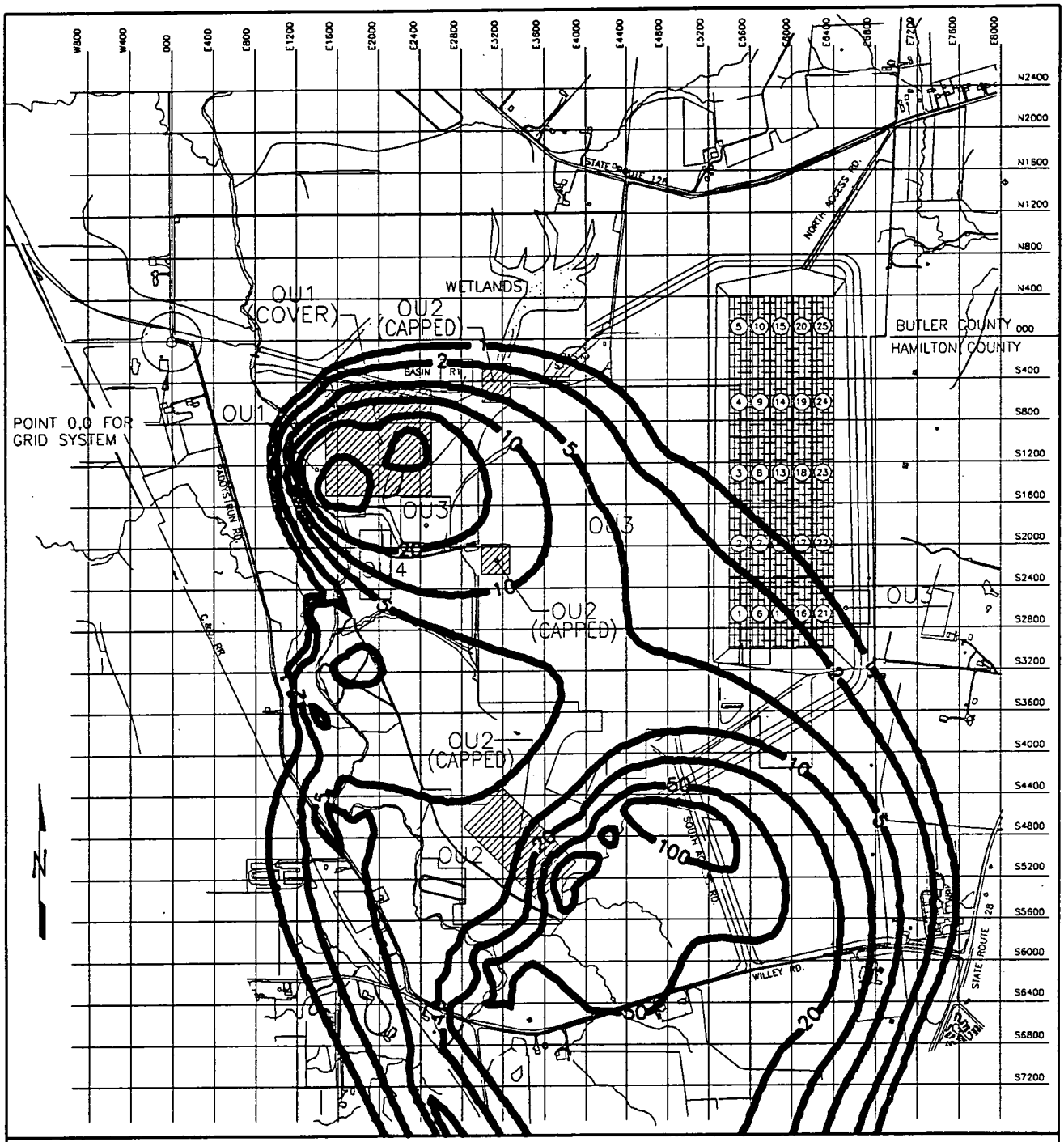

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SCALE IN FEET

10 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 181.7 ppb

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FIGURE 1.6-9
U238 GROUNDWATER CONCENTRATIONS AT 70 YEARS
FOR FUTURE LAND USE SCENARIO

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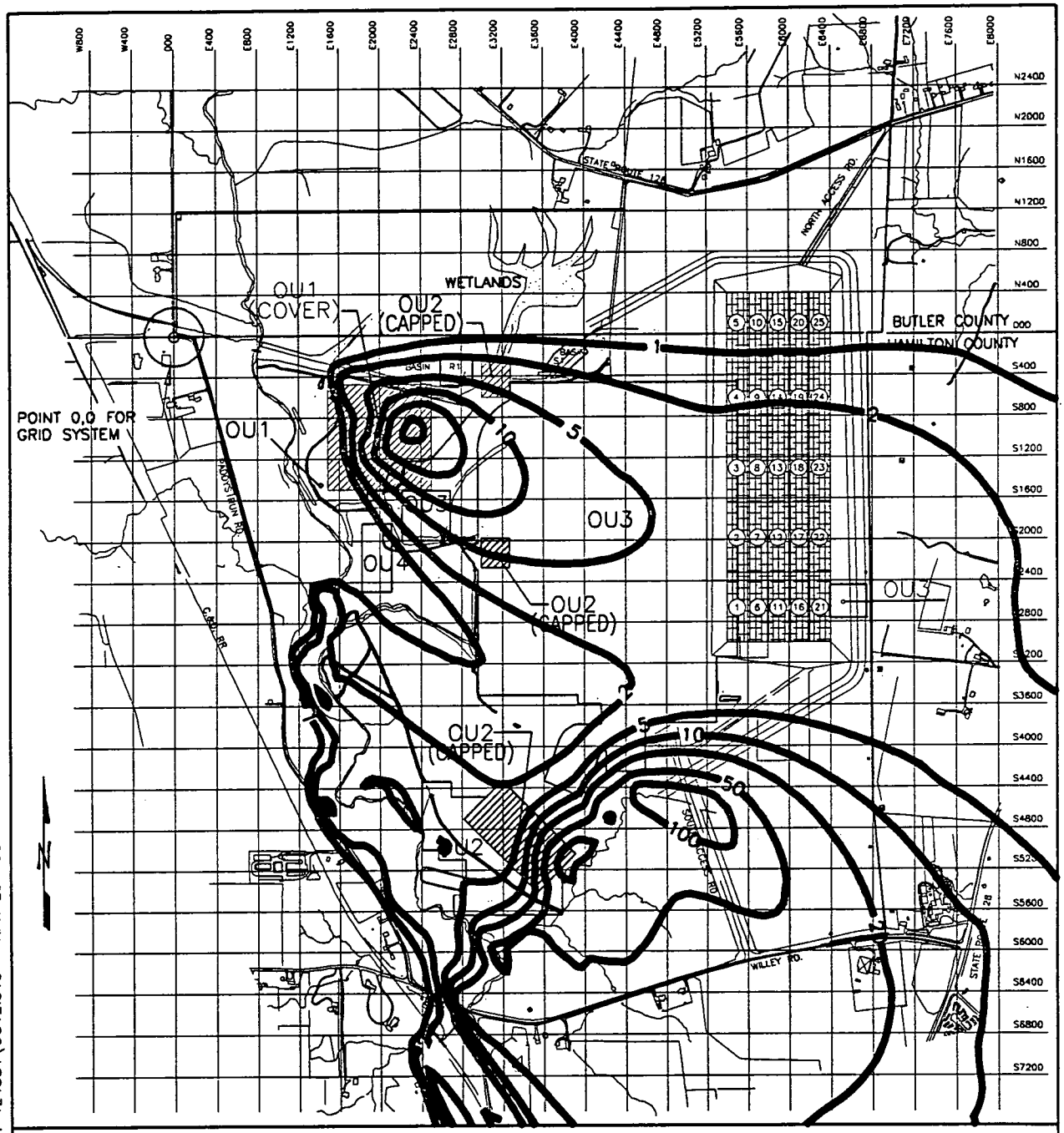

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SCALE IN FEET

10 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 173.8 ppb

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FIGURE 1.6-10
U238 GROUNDWATER CONCENTRATIONS AT 1000 YEARS

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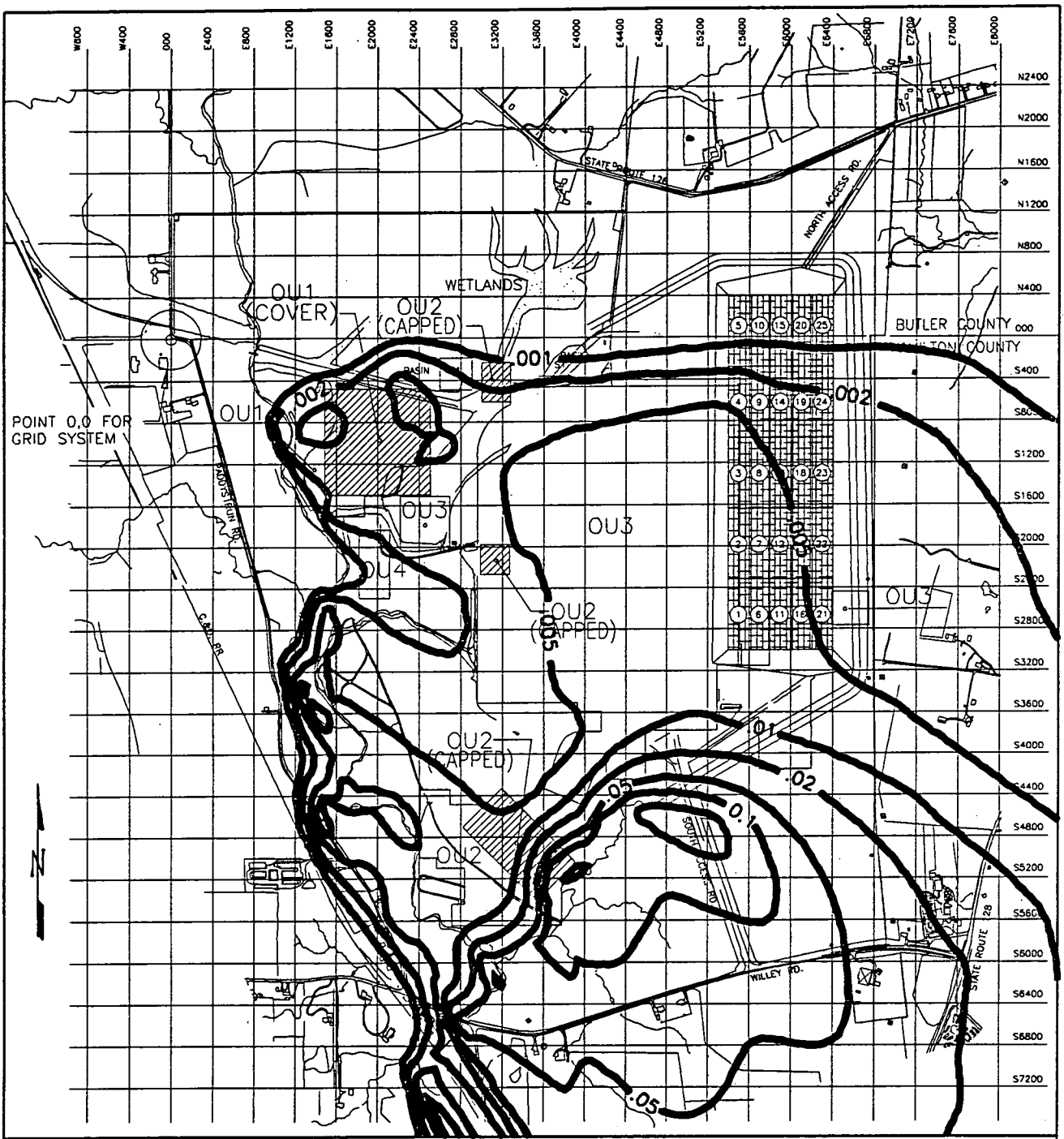

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SCALE IN FEET

.01 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 0.308 ppb

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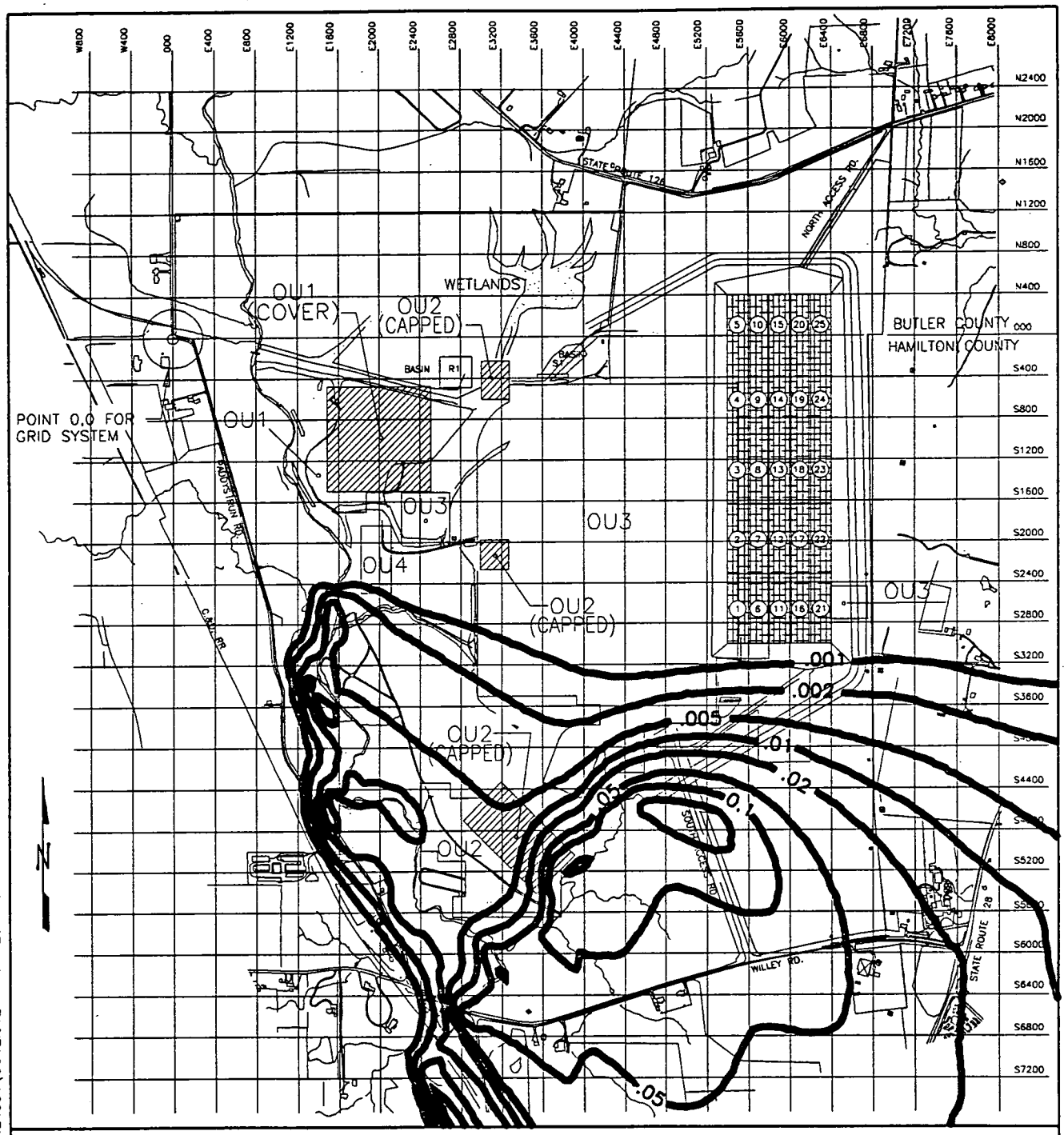
FIGURE 1.6-11
TC-99 GROUNDWATER CONCENTRATIONS AT 70 YEARS
FOR FUTURE LAND USE SCENARIO



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SCALE IN FEET

.01 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 0.306 ppb

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FIGURE 1.6-12
TC-99 GROUNDWATER CONCENTRATIONS AT 1000 YEARS

Figures I.6-13 through I.6-16 present the concentration contours for Np-237, Aroclor-1221, antimony, and cadmium at the 1000-year point for the Future Land Use scenario. This is the time when each of these COCs reaches its maximum concentration at any point in the aquifer. Operable Unit 1 is a significant source for all of these COCs. The effect of surface water recharge can particularly be seen in the contours for antimony (Figure I.6-16). These COCs are not expected to contribute significantly to the site-wide risk when compared to the impact of the uranium isotopes and Tc-99.

The general process for selecting receptor locations is described in Section I.5.1.4. For the specific locations of groundwater receptors, the U-238 and Tc-99 contour plots were reviewed and a limited number of potential locations were selected for both on- and off-property receptors. These potential receptor locations were selected in areas where both U-238 and Tc-99 reached maximum values. COC concentrations with time were listed at each of these points. Then, to be conservative, a method was developed to determine both the location and the 10-year interval over which the greatest ILCR was estimated, for an adult RME receptor who ingested 2 liters of groundwater per day over a 70-year lifetime. For each 10-year interval of the groundwater modeling output, and for each potential receptor location, the ILCR was estimated for each modeled COC (which had an appropriate cancer slope factor). The resulting individual cancer risks were summed for each location over the 10-year interval. The single location where the RME receptor would experience the greatest total ILCR for all COCs for the groundwater (over each 70 or 1000 years of groundwater modeling output) was chosen as the representative receptor location for each scenario. One receptor location was selected for the maximum on-property risk, and one for the maximum off-property risk. These locations are shown on Figure I.6-17.

Figures I.6-18 and I.6-19 present changes in estimated groundwater U-238 concentrations with time for these receptors under the Current and Future Land Use scenarios, respectively. Figure I.6-20 presents the comparable data for Tc-99 under the Future Land Use scenarios.

The process for locating a perched-water receptor was similar to that of the groundwater receptor. The initial leachate concentrations in Table I.6-2 (Section I.6.1.3.1) were assumed to represent potential perched-zone concentrations for the COCs after remediation. Several potential receptor locations were selected in the central portion of the FEMP, where the perched

zone is known to exist. Locations were selected where the listed COC concentrations are at the highest values. The total ILCR was then calculated for each location. The Plant 2/3 area was found to have the highest total ILCR for perched-water concentrations derived from the initial leachate concentrations. A perched-water receptor has been located in this area, as shown in Figure I.6-17.

The estimated contaminant concentrations in perched water and groundwater at each receptor point are evaluated further in Section I.8.0 to quantify the exposure values they represent. The risks represented by these and other COC exposures are then characterized in Section I.9.0.

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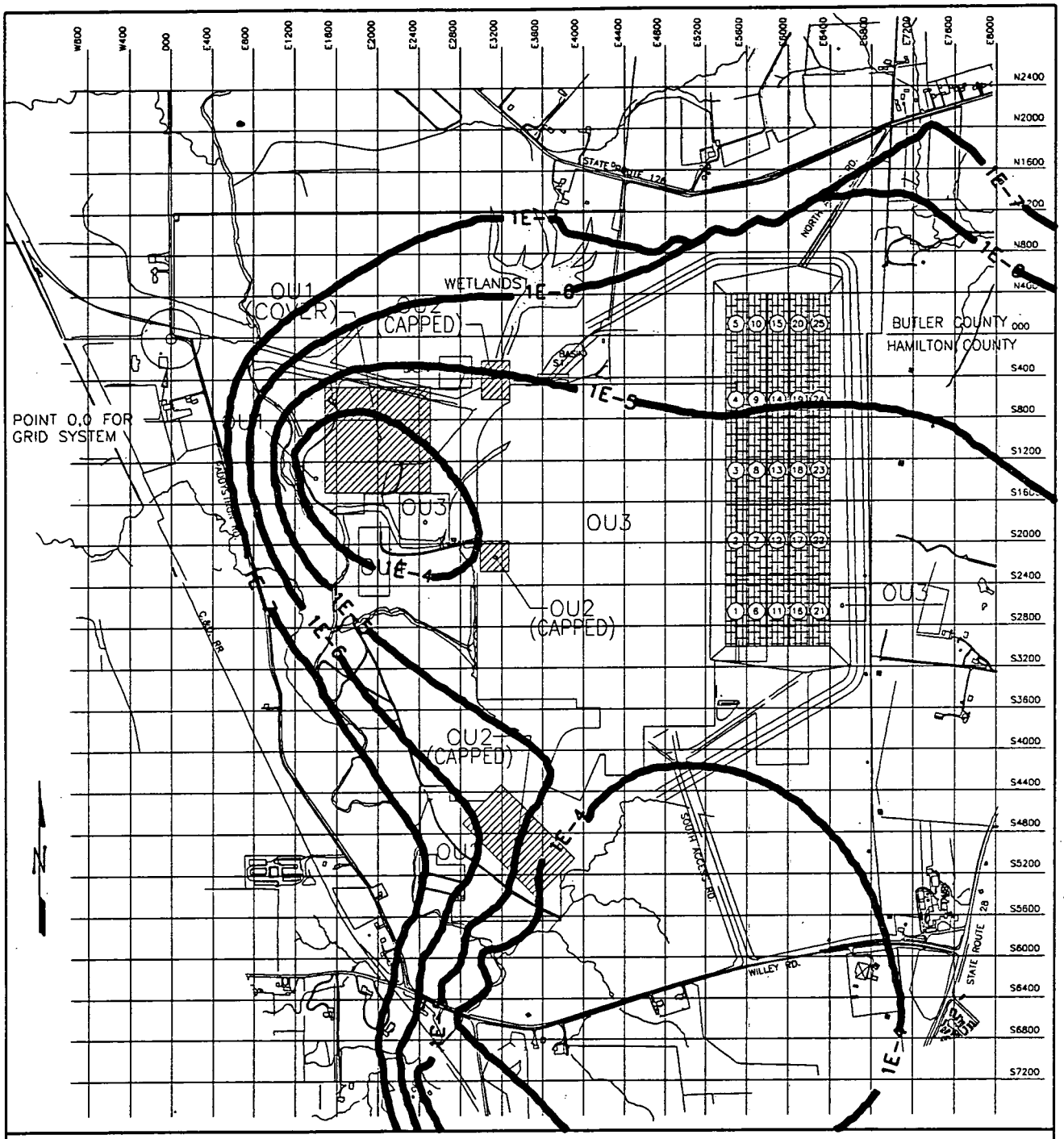

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SCALE IN FEET

1E-5 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 9.063E-04 ppb

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FIGURE 1.6-13
NP-237 GROUNDWATER CONCENTRATIONS AT 1000 YEARS

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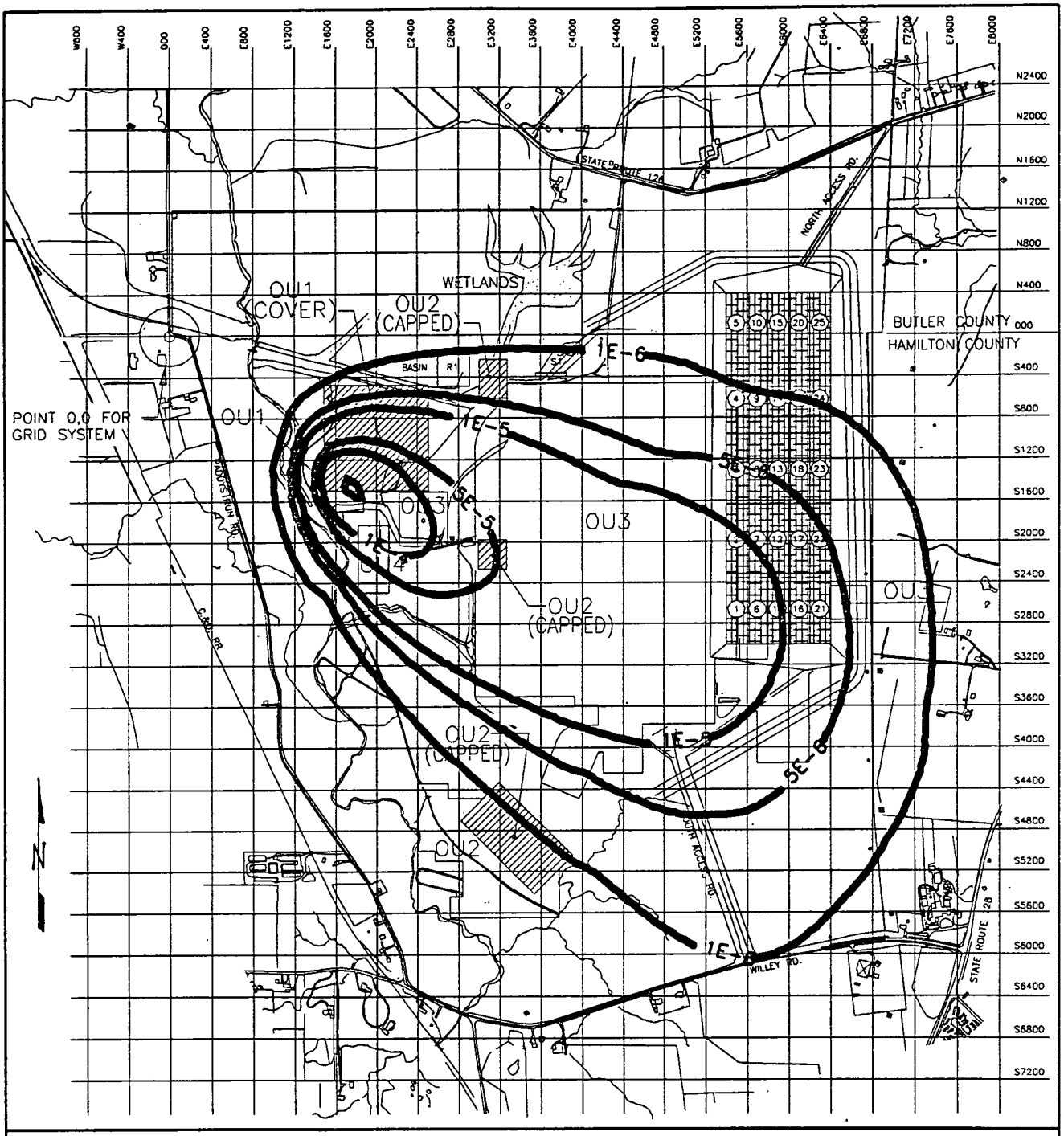

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SCALE IN FEET

1E-5 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 5.453E-04 ppb

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FIGURE 1.6-14
AROCLOR-1221 GROUNDWATER CONCENTRATIONS AT 1000 YEARS

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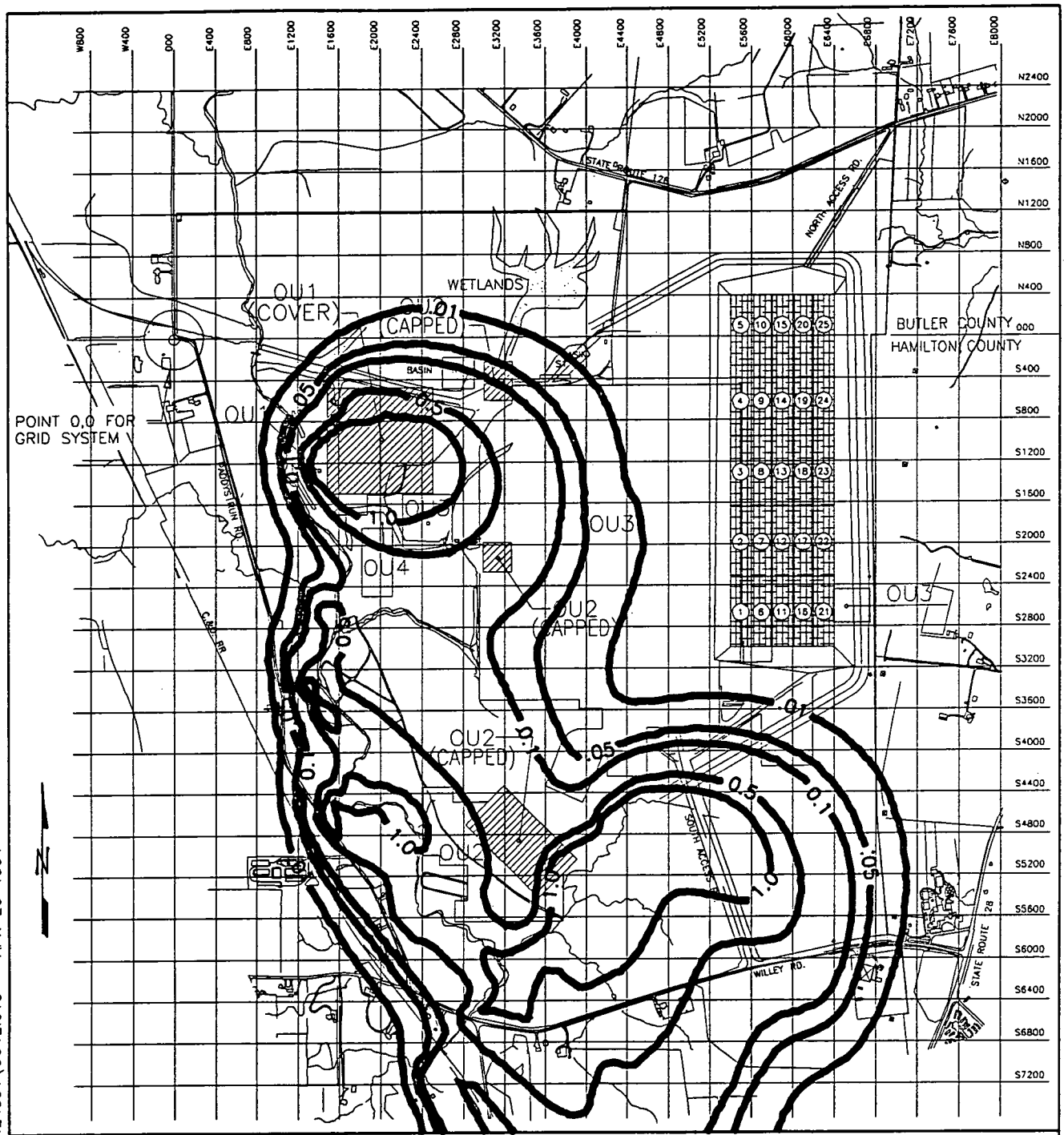

400 0 400 800
SCALE IN FEET

.01 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 3.435 ppb

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OU12 CRARE ACAD FILE: 424331\OU12I615 APR 29 1994

FIGURE 1.6-15
CONCENTRATION CONTOURS AT LAYER 1 WITHOUT RETENTION BASINS
ANTIMONY AT 1000 YEARS

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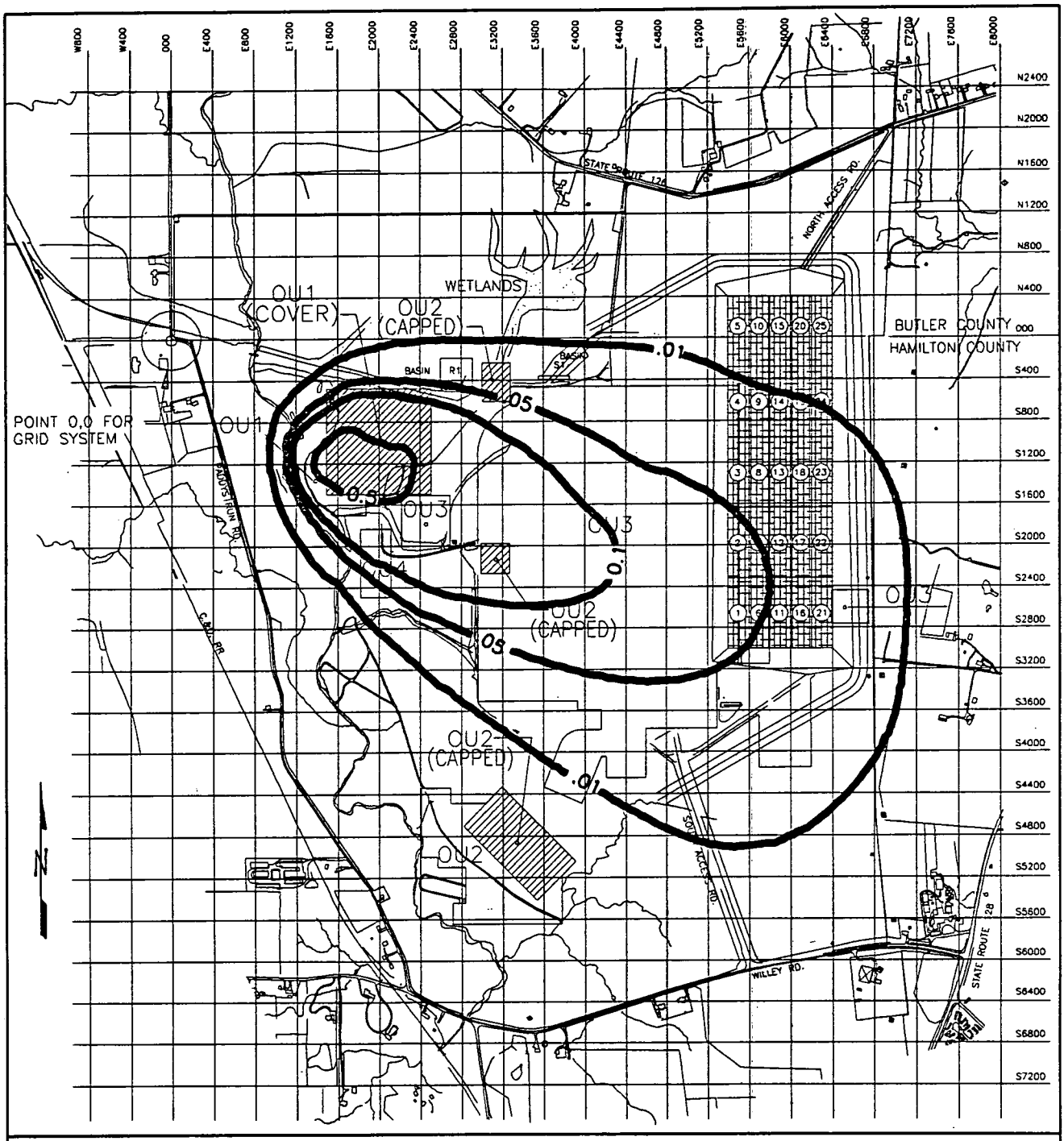

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SCALE IN FEET

.01 CONCENTRATION ISOPLETHS ARE IN PARTS PER BILLION

MAX CONCENTRATION = 0.9748 ppb

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FIGURE 1.6-16
CADMIUM GROUNDWATER CONCENTRATIONS AT 1000 YEARS

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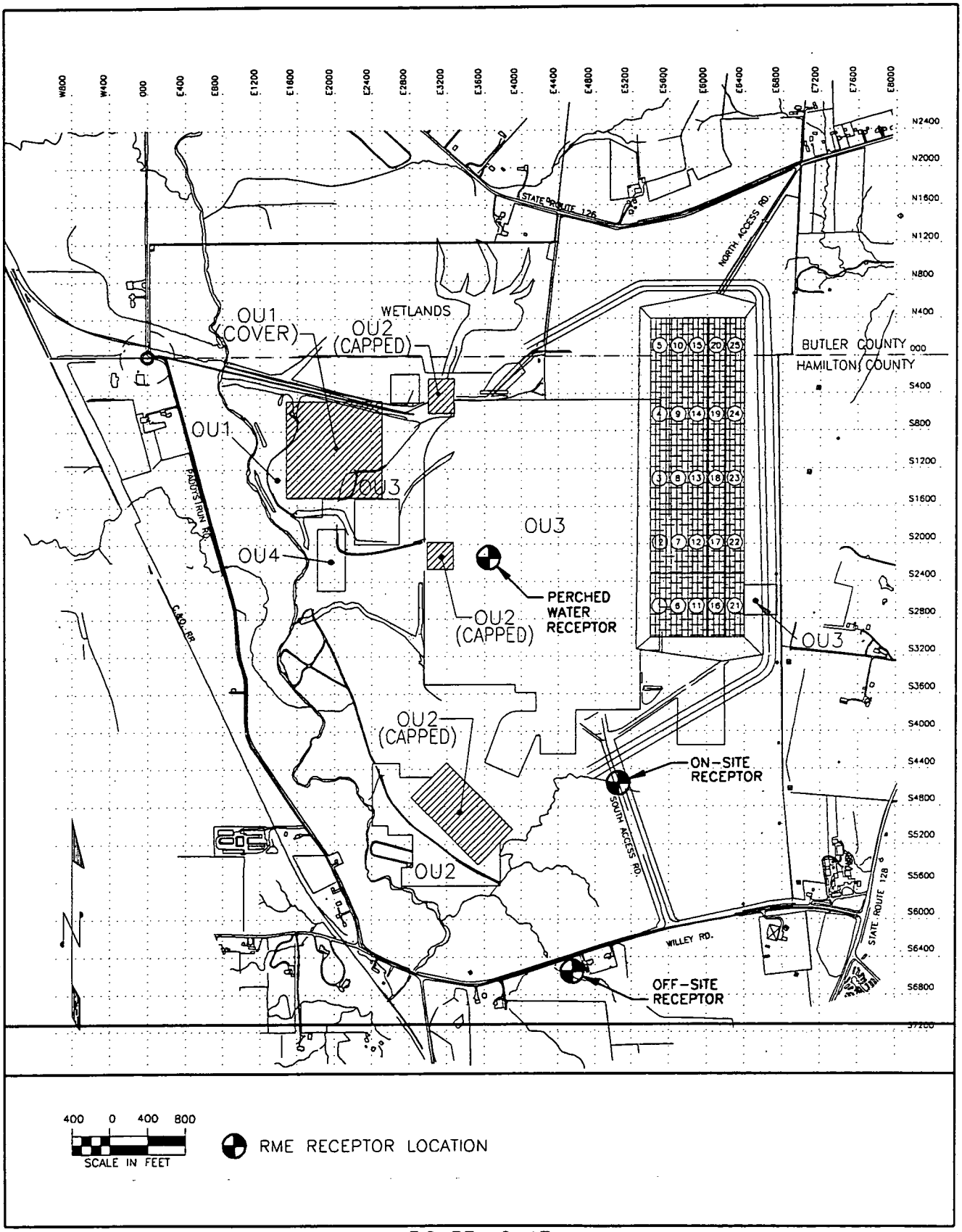

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FIGURE 1.6-17
GROUNDWATER RECEPTOR LOCATIONS

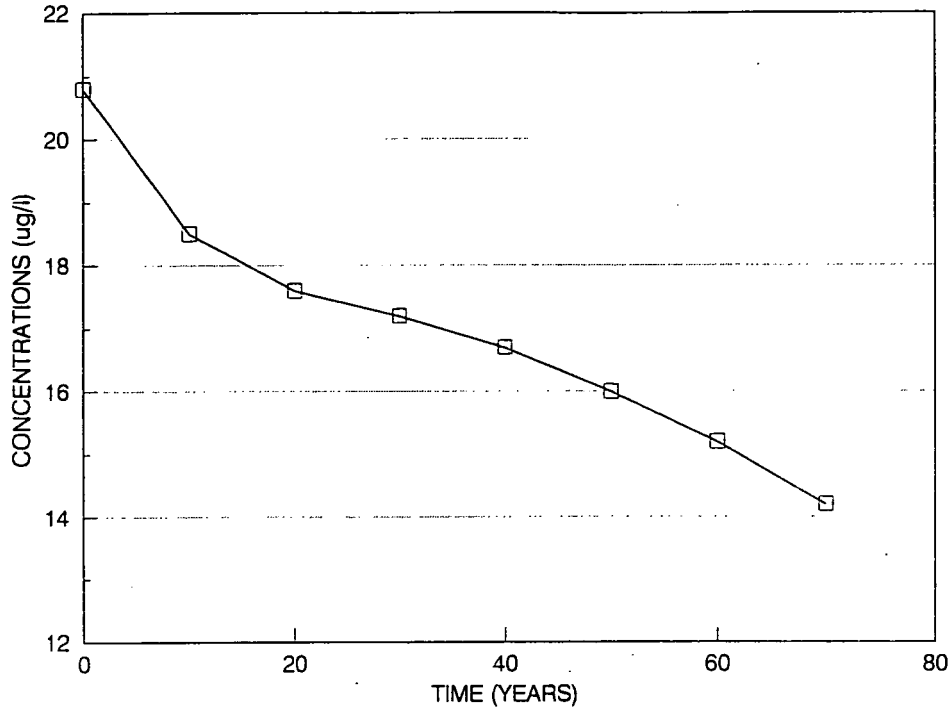

FIGURE I.6-18
U-238 GROUNDWATER CONCENTRATIONS VS TIME FOR CURRENT LAND USE RECEPTORS

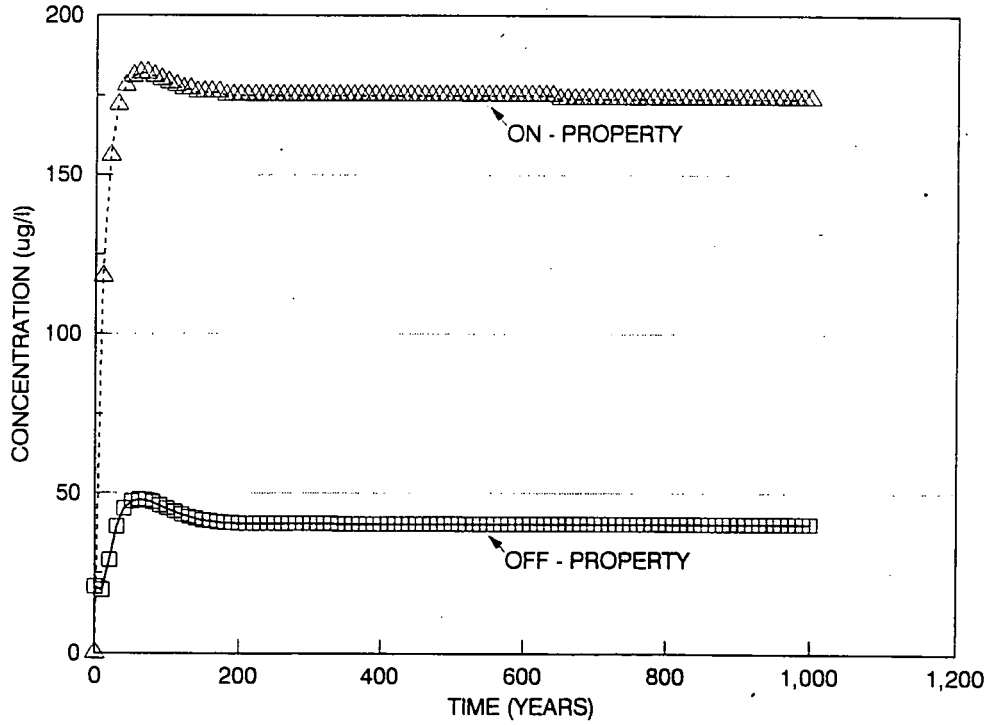

FIGURE I.6-19
U-238 GROUNDWATER CONCENTRATIONS VS TIME FOR FUTURE LAND USE RECEPTORS

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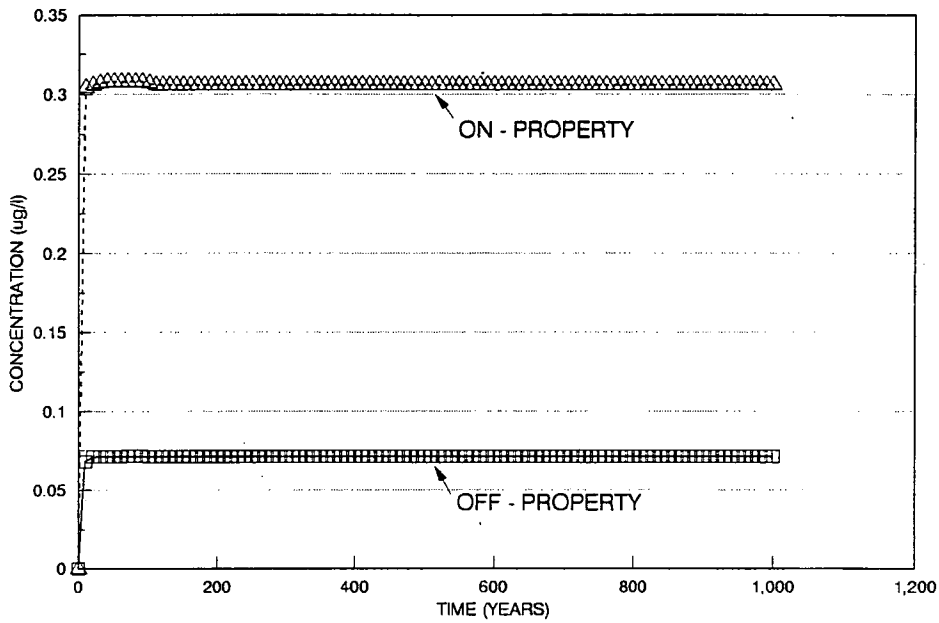

FIGURE I.6-20
Tc-99 GROUNDWATER CONCENTRATIONS VS TIME FOR FUTURE LAND USE RECEPTORS

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I.6.2 AIR TRANSPORT MODELING

This section presents the approach, methodology, and results of the CRARE air transport analysis. The objective of this analysis was to determine the maximum on- 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 (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 nonvolatile organic compounds. The only gas-phase contaminant evaluated in this analysis was Rn-222. VOCs were not analyzed as they would be lost to the atmosphere prior to the start of the postremediation periods analyzed in the CRARE. The air dispersion model accounted for dispersion and dilution of the contaminants under defined meteorological conditions, such as wind speed and direction, atmospheric stability, and mixing height. The parameters used were collected from an on-property meteorological station and the National Weather Service in Dayton, Ohio.

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

1. Scenarios for the air transport analysis were defined.
2. Sources of air emissions and contaminants released were identified based on site-specific information.
3. The appropriate EPA regulatory air dispersion model was selected which best represented the site characteristics and the objective of the analysis.
4. 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.
5. Results of the air dispersion model were processed to determine the maximum on- and off-property annual average concentration for residual risk.

Figure I.6-21 presents the sequence of these steps and the sections below that describe them.

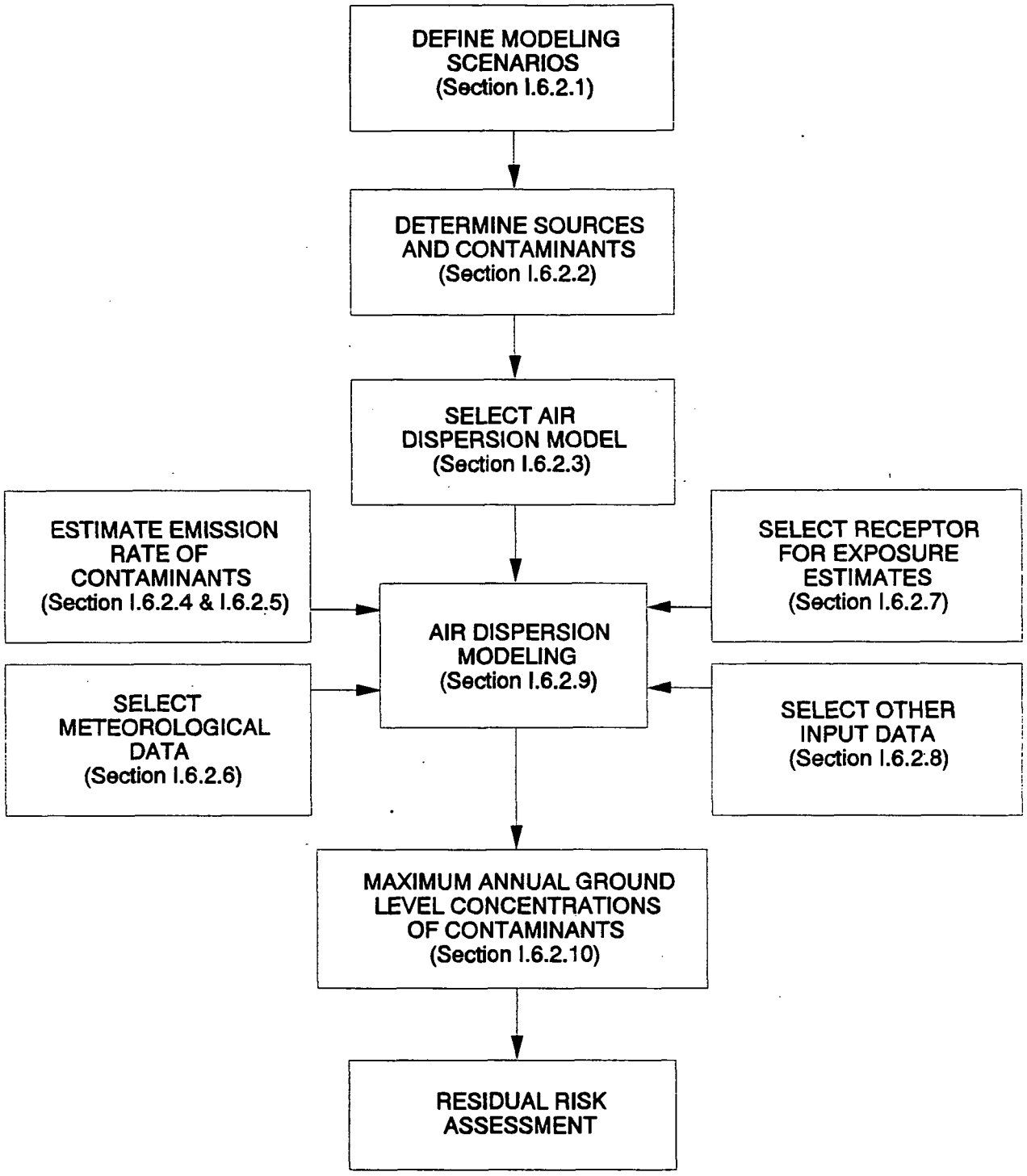

FIGURE I.6-21

SEQUENTIAL BLOCK DIAGRAM OF AIR TRANSPORT ANALYSIS

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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 make the results relevant to the site so that the risk associated with the air exposure pathway was realistic.

I.6.2.1 Source Term Assumptions for Air Transport Analysis

The residual risk from the remediated FEMP were evaluated for three general scenarios: the Current Land Use, the Future Land Use With Federal Ownership, and the Future Land Without Federal Ownership. The two future land-use scenarios do not include continued maintenance of the on-property disposal facilities or capped areas with the only distinction being the location of the receptors. Therefore, the air emission source terms for the future land-use scenarios are assumed to be identical. As shown in the Operable Unit 4 CRARE (DOE 1993i), the difference between Current Land Use and Future Land Use source terms is trivial. Therefore, only the Future Land Use source terms are analyzed in this CRARE.

A number of 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, 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 are included for the Operable Unit 1 covered area, the Operable Unit 2 Solid-Waste Landfill, Lime Sludge Pond, and Consolidation Area caps or the Operable Unit 3 Disposal Vaults.

Particulate matter and radon emissions were estimated for exposed soil in Operable Units 1, 2, 4, and 5. For Operable Unit 1, this soil included approximately 11 acres of ground within the battery limits but not covered with the cap. For Operable Unit 2, this soil included the lower till layer exposed after remedial excavation in the Inactive Flyash Pile and Active Flyash Pile, and the exposed fill layer after remedial excavation in the South Field. For Operable Unit 4, this soil included subsurface soil which was assumed to be exposed following the loss of 6 inches of clean

cover soil. For Operable Unit 5, this soil included existing surface soil for the remainder of the FEMP. The materials and soil imported for cap layers and cover soil were assumed to be uncontaminated and would not contribute to air contaminant emissions.

I.6.2.2 Sources and Contaminants

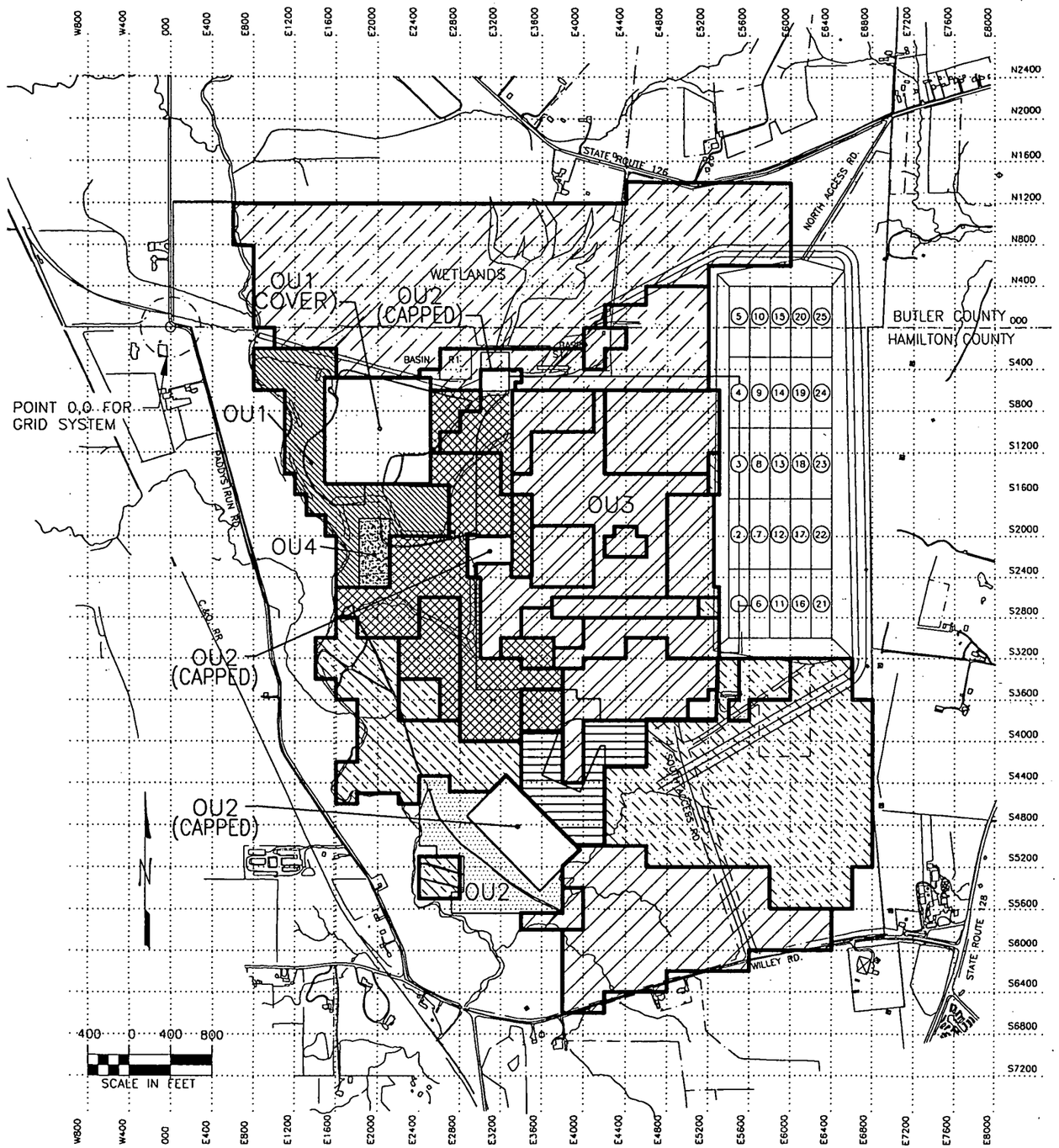
All sources considered for this study were analyzed as ground-level area sources. The particulate emission sources included the exposed soils in Operable Units 1, 2, 4, and 5. To analyze emission impacts, 531 area sources were evaluated in 29 source groups. Figure I.6-22 shows the source group locations and sizes used in the air dispersion model for areas associated with Operable Units 1 through 5. Note that soil beneath Operable Unit 3 is considered part of Operable Unit 5.

I.6.2.3 Air Transport Models

The annual average contaminant concentrations were determined using ISCLT2, the model 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.

I.6.2.4 Particulate Contaminant Emission Rates

Radionuclide, inorganic, and nonvolatile organic contaminants were assumed to be present 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}).



LEGEND

- OU5 – AREA 560 CONSISTS OF SOURCE GROUPS 560A (61 SOURCES), 560B (19 SOURCES), AND 560C (3 SOURCES).
- OU5 – AREA 570 CONSISTS OF SOURCE GROUPS 570A (36 SOURCES), 570B (1 SOURCE), 570C (2 SOURCES), 570D (17 SOURCES), AND 570E (6 SOURCES).
- OU5 – AREA 575 CONSISTS OF SOURCE GROUPS 575A (30 SOURCES) AND 575B (1 SOURCE).
- OU5 – AREA 580 CONSISTS OF SOURCE GROUP 580A (14 SOURCES).
- OU5 – AREA 581 CONSISTS OF SOURCE GROUPS 581A (74 SOURCES) AND 581B (7 SOURCES).
- OU5 – AREA 582 CONSISTS OF SOURCE GROUPS 582A (36 SOURCES) 582B (4 SOURCES).
- OU5 – AREA PA CONSISTS OF SOURCE GROUPS PAA (4 SOURCES), PAB (7 SOURCES), PAC (4 SOURCES), PAD (4 SOURCES), PAE (7 SOURCES), PAF (7 SOURCES), PAG (2 SOURCES), PAH (70 SOURCES), AND PAI (20 SOURCES).
- OU4 – CONSISTS OF ONE SOURCE GROUP (10 SOURCES).
- OU2 – SOUTH FIELD AREA CONSISTS OF SOURCE GROUPS AFP (25 SOURCES), IFP (8 SOURCES), AND SF (32 SOURCES).
- OU1 – UNCAPPED AREA CONSISTS OF SOURCE GROUP WPAA (20 SOURCES).

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FIGURE 1.6-22 SOURCE LOCATIONS FOR AIR DISPERSION MODELING

I.6.2.4.1 Contaminated Soil Concentrations

The estimated radionuclide contaminant concentrations used for development of emission source terms are presented in Table I.6-9. The estimated chemical contaminant concentrations used are presented in Table I.6-10. Contaminant soil concentrations were selected from data in the RI/FS database and data presented in the following documents:

- *Site-Wide Characterization Report* (DOE 1993e)
- *Feasibility Study Report for Operable Unit 1* (DOE 1993g)
- *Remedial Investigation Report for Operable Unit 2* (DOE 1994a)
- *Feasibility Study Report for Operable Unit 2* (DOE 1994a)
- *Remedial Investigation Report for Operable Unit 4* (DOE 1993d)
- *Feasibility Study Report for Operable Unit 4*, Appendix A (DOE 1993h)
- *Proposed Plan for Remedial Actions at Operable Unit 4* (DOE 1993h)

In this CRARE, cleanup levels were based on the RI/FSs for Operable Units 1, 2, and 4 and the SWCR for Operable Units 3 and 5. The SWCR was used to supplement the data presented in the Operable Unit 2 RI reports, Operable Unit 4 RI/FS reports and Proposed Plan, as well as the RI/FS database. Because this analysis assumed that the site has been remediated, any soil concentrations exceeding the cleanup levels identified in the Operable Unit 1, 2, and 4 FS reports or in the SWCR were reset to the cleanup level. This procedure directly affected the soil concentrations of Cs-137, Np-237, radium, thorium, and uranium isotopes used in the analysis.

For areas in Operable Unit 5 which exceeded the U-238 cleanup level, the average composition of total uranium on the site was used to estimate concentrations of U-234, U-235, and U-236 from the U-238 concentration (60 pCi/g) in treated (washed) soil. The approximate compositions are 0.0896, 0.685, 0.0093 and 99.3 percent (by weight) of U-234, U-235, U-236, and U-238, respectively. Since soil washing is a chemical process, the relative abundance of the uranium isotopes will not change. However, areas in Operable Unit 5 which did not require remediation of U-238 were assumed to have the U-234, U-235, and U-236 soil concentrations provided in the RI/FS database.

TABLE I.6-9

ESTIMATED RADIONUCLIDE CONCENTRATIONS (pCi/g) IN SURFACE SOIL/COVER SOIL

Radionuclide	OU2 Active Flyash Residual: Exposed Soil	OU2 Inactive Flyash Residual: Exposed Soil	OU2 South Field Residual Exposed Soil	OU4 Residual: Exposed Soil
Cs-137	NC	ND	ND	2.30×10^{-1} [b]
Np-237	1.81×10^{0} [a]	1.72×10^{-1} [a]	2.87×10^{0} [a]	NC
Pa-231	NC	NC	NC	1.37×10^{1} [b]
Pb-210	ND	ND	ND	1.96×10^{1} [b]
Pu-238	ND	ND	ND	NC
Pu-239	ND	ND	ND	NC
Pu-240	ND	ND	ND	NC
Ra-226	9.56×10^{-1} [a]	9.24×10^{-1} [a]	8.95×10^{-1} [a]	2.00×10^{0} [c]
Ra-228	7.77×10^{-1} [a]	6.08×10^{-1} [a]	7.83×10^{-1} [a]	2.00×10^{0} [c]
Ru-106	NC	ND	ND	NC
Sr-90	ND	ND	ND	1.80×10^{0} [d]
Tc-99	ND	ND	ND	3.60×10^{0} [d]
Th-228	1.55×10^{0} [a]	5.75×10^{-1} [a]	6.43×10^{-1} [a]	1.93×10^{0} [b]
Th-230	2.25×10^{0} [a]	1.87×10^{0} [a]	1.21×10^{0} [a]	5.00×10^{0} [e]
Th-232	1.12×10^{0} [a]	5.05×10^{-1} [a]	5.95×10^{-1} [a]	5.00×10^{0} [e]
U-234	9.73×10^{-1} [a]	9.62×10^{-1} [a]	2.26×10^{0} [a]	3.47×10^{1} [f]
U-235	2.3×10^{-2} [a]	6.90×10^{-2} [a]	1.34×10^{-1} [a]	9.22×10^{-1} [f]
U-236	2.3×10^{-2} [a]	6.90×10^{-2} [a]	1.34×10^{-1} [a]	3.81×10^{-1} [f]
U-238	9.5×10^{-1} [a]	1.21×10^{0} [a]	2.89×10^{0} [a]	2.08×10^{1} [d]

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NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-9
(Continued)

Radionuclide	OU5 Residual: Surface Soil [g] in Area 560a	OU5 Residual: Surface Soil [g] in Area 560b	OU5 Residual: Surface Soil [g] in Area 560c	OU5 Residual: Surface Soil [g] in Area 570a
Cs-137	6.50×10^{-1}	1.00×10^{0}	1.00×10^{0}	6.00×10^{-1}
Np-237	NC	NC	NC	NC
Pa-231	NC	NC	NC	NC
Pb-210	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}
Pu-238	NC	NC	2.20×10^{0}	NC
Pu-239	NC	NC	2.90×10^{0}	NC
Pu-240	NC	NC	1.06×10^{1}	NC
Ra-226	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Ra-228	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}
Ru-106	NC	NC	NC	NC
Sr-90	6.00×10^{-1}	2.30×10^{0}	NC	1.80×10^{0}
Tc-99	4.50×10^{-1}	1.05×10^{1}	1.84×10^{1}	7.00×10^{-1}
Th-228	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Th-230	1.75×10^{0}	2.50×10^{0}	5.00×10^{0}	2.19×10^{0}
Th-232	9.90×10^{-1}	1.00×10^{0}	5.00×10^{0}	8.60×10^{-1}
U-234	4.16×10^{0}	3.43×10^{1}	1.00×10^{2}	5.81×10^{0}
U-235	3.00×10^{-1}	1.00×10^{0}	2.66×10^{0}	1.10×10^{0}
U-236	8.81×10^{0}	9.00×10^{0}	1.10×10^{0}	9.00×10^{0}
U-238	4.70×10^{0}	1.99×10^{1}	6.00×10^{1}	6.97×10^{0}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-9
(Continued)

Radionuclide	OU5 Residual Surface Soil in Area 570b	OU5 Residual Surface Soil [g] in Area 570c	OU5 Residual: Surface Soil [g] in Area 570d	OU5 Residual: Surface Soil [g] in Area 570e	OU5 Residual: Surface Soil [g] in Area 575a
Cs-137	9.20×10^{-1}	5.00×10^{-1}	1.00×10^{0}	9.20×10^{-1}	6.00×10^{-1}
Np-237	NC	NC	NC	NC	NC
Pa-231	NC	NC	NC	NC	NC
Pb-210	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}
Pu-238	NC	NC	9.00×10^{-1}	NC	NC
Pu-239	NC	NC	NC	NC	NC
Pu-240	NC	NC	NC	NC	NC
Ra-226	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Ra-228	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}
Ru-106	NC	NC	NC	NC	NC
Sr-90	1.10×10^{0}	7.00×10^{-1}	2.45×10^{0}	1.10×10^{0}	NC
Tc-99	NC	NC	1.70×10^{0}	NC	2.00×10^{-1}
Th-228	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Th-230	5.00×10^{0}	1.50×10^{0}	5.00×10^{0}	5.00×10^{0}	1.80×10^{0}
Th-232	5.00×10^{0}	8.00×10^{-1}	5.00×10^{0}	5.00×10^{0}	8.00×10^{-1}
U-234	2.05×10^{1}	1.18×10^{1}	1.00×10^{2}	2.05×10^{1}	1.90×10^{0}
U-235	1.41×10^{0}	9.00×10^{-1}	2.66×10^{0}	1.41×10^{0}	1.00×10^{-1}
U-236	9.00×10^{0}	9.00×10^{0}	1.10×10^{0}	9.00×10^{0}	2.94×10^{0}
U-238	2.03×10^{1}	1.19×10^{1}	6.00×10^{1}	2.03×10^{1}	2.50×10^{0}

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NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-9
(Continued)

Radionuclide	OU5 Residual: Surface Soil [g] in Area 575b	OU5 Residual: Surface Soil [g] in Area 580a	OU5 Residual: Surface Soil in Area 581a	OU5 Residual Surface Soil [g] in Area 581b
Cs-137	1.00×10^{0}	5.40×10^{-1}	4.54×10^{-1}	1.00×10^{0}
Np-237	NC	NC	2.02×10^{-1}	NC
Pa-231	NC	NC	NC	NC
Pb-210	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}
Pu-238	NC	NC	NC	8.50×10^{-1}
Pu-239	NC	NC	NC	NC
Pu-240	NC	NC	NC	NC
Ra-226	4.00×10^{-1}	3.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Ra-228	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}
Ru-106	NC	5.20×10^{-1}	NC	NC
Sr-90	NC	NC	1.00×10^{0}	1.68×10^{0}
Tc-99	2.00×10^{-1}	NC	5.30×10^{0}	7.50×10^{-1}
Th-228	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Th-230	1.70×10^{0}	1.20×10^{0}	1.95×10^{0}	2.80×10^{0}
Th-232	7.00×10^{-1}	8.00×10^{-1}	9.87×10^{-1}	1.20×10^{0}
U-234	5.40×10^{0}	1.30×10^{0}	5.90×10^{0}	2.24×10^{1}
U-235	8.79×10^{-2}	1.41×10^{0}	6.00×10^{-1}	1.40×10^{0}
U-236	2.58×10^{0}	9.00×10^{0}	9.00×10^{0}	9.00×10^{0}
U-238	5.80×10^{0}	1.80×10^{0}	5.70×10^{0}	2.35×10^{1}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-9
(Continued)

Radionuclide	OU5 Residual: Surface Soil [g] in Area 582a	OU5 Residual: Surface Soil [g] in Area 582b	OU5 Residual: Surface Soil [g] in Area PAa	OU5 Residual: Surface Soil [g] in Area PAb
Cs-137	8.00×10^{-1}	1.00×10^{0}	5.27×10^{-1}	4.69×10^{0}
Np-237	NC	5.00×10^{0}	1.56×10^{-1}	NC
Pa-231	NC	NC	NC	NC
Pb-210	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}
Pu-238	6.00×10^{-1}	6.99×10^{-1}	1.00×10^{-1}	NC
Pu-239	NC	3.02×10^{-1}	NC	NC
Pu-240	NC	1.10×10^{0}	NC	NC
Ra-226	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Ra-228	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}
Ru-106	NC	NC	NC	NC
Sr-90	1.20×10^{0}	4.49×10^{0}	8.60×10^{-1}	2.09×10^{0}
Tc-99	4.00×10^{-1}	1.42×10^{2}	1.00×10^{0}	3.89×10^{0}
Th-228	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Th-230	5.00×10^{0}	3.71×10^{0}	5.00×10^{0}	5.00×10^{0}
Th-232	1.50×10^{0}	2.70×10^{0}	1.70×10^{0}	2.00×10^{0}
U-234	4.64×10^{0}	3.60×10^{0}	7.48×10^{2}	1.00×10^{2}
U-235	1.00×10^{-1}	2.00×10^{-1}	3.70×10^{0}	2.66×10^{0}
U-236	2.94×10^{0}	5.87×10^{0}	9.00×10^{0}	1.10×10^{0}
U-238	7.00×10^{0}	3.60×10^{0}	3.00×10^{1}	6.00×10^{1}

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NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-9
(Continued)

Radionuclide	OU5 Residual: Surface Soil [g] in Area PAc	OU5 Residual: Surface Soil in Area PAd	OU5 Residual Surface Soil [g] in Area PAe	OU5 Residual: Surface Soil [g] in Area PAf
Cs-137	2.00×10^{-1}	7.65×10^{-1}	4.69×10^{-1}	7.65×10^{-1}
Np-237	2.63×10^{0}	NC	7.10×10^{-1}	NC
Pa-231	NC	NC	NC	NC
Pb-210	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}
Pu-238	7.18×10^{-1}	NC	NC	1.70×10^{0}
Pu-239	6.34×10^{-1}	NC	1.51×10^{0}	1.10×10^{0}
Pu-240	2.31×10^{0}	NC	5.50×10^{0}	4.00×10^{0}
Ra-226	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Ra-228	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}
Ru-106	NC	NC	NC	NC
Sr-90	8.40×10^{-1}	6.44×10^{-1}	6.05×10^{0}	7.00×10^{-1}
Tc-99	2.73×10^{0}	NC	2.40×10^{0}	1.80×10^{0}
Th-228	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Th-230	5.00×10^{0}	1.50×10^{0}	5.00×10^{0}	5.00×10^{0}
Th-232	2.25×10^{0}	1.48×10^{0}	5.00×10^{0}	5.00×10^{0}
U-234	1.00×10^{2}	1.00×10^{2}	1.00×10^{2}	1.00×10^{2}
U-235	2.66×10^{0}	2.66×10^{0}	2.66×10^{0}	2.66×10^{0}
U-236	1.10×10^{0}	1.10×10^{0}	1.10×10^{0}	1.10×10^{0}
U-238	6.00×10^{1}	6.00×10^{1}	6.00×10^{1}	6.00×10^{1}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

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TABLE I.6-9
(Continued)

Radionuclide	OU5 Residual: Surface Soil [g] in Area PAg	OU5 Residual: Surface Soil [g] in Area PAh	OU5 Residual: Surface Soil [g] in Area PAi	OU5 Residual: Surface Soil [g] in Area WPAa
Cs-137	1.00×10^{0}	4.00×10^{-1}	5.40×10^{-1}	2.00×10^{-1}
Np-237	NC	2.70×10^{-1}	NC	NC
Pa-231	NC	NC	NC	NC
Pb-210	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	3.98×10^{0}
Pu-238	4.00×10^{1}	3.00×10^{-2}	NC	NC
Pu-239	5.30×10^{0}	2.00×10^{-2}	NC	NC
Pu-240	1.93×10^{1}	7.28×10^{-2}	NC	NC
Ra-226	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Ra-228	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}	7.00×10^{-1}
Ru-106	NC	9.10×10^{-1}	5.20×10^{-1}	NC
Sr-90	8.00×10^{-1}	6.00×10^{-1}	NC	6.00×10^{-1}
Tc-99	3.20×10^{2}	1.00×10^{0}	NC	4.50×10^{-1}
Th-228	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}	4.00×10^{-1}
Th-230	5.00×10^{0}	3.10×10^{0}	2.24×10^{0}	5.00×10^{0}
Th-232	5.00×10^{0}	1.10×10^{0}	8.60×10^{-1}	1.10×10^{0}
U-234	1.00×10^{2}	1.00×10^{2}	1.22×10^{0}	3.90×10^{0}
U-235	2.66×10^{0}	2.66×10^{0}	9.00×10^{0}	8.00×10^{-1}
U-236	1.10×10^{0}	1.10×10^{0}	9.00×10^{0}	9.00×10^{0}
U-238	6.00×10^{1}	6.00×10^{1}	1.80×10^{0}	9.70×10^{0}

NC = Not characterized
ND = Not detected

[a]From OU2 Till and GMA Concentrations (ALL-SUM.WK1), March 1994.
[b]From OU4 RI Report (Berms and/or Surface Soil) (DOE 1993d)
[c]From OU4 PP Report (Soil Cleanup Level) (DOE 1993h)
[d]From OU4 FS Report (Berm, Surface or Subsurface Soil) (DOE 1993h)
[e]From SWCR ARAR (Part III) (DOE 1993e)
[f]Based on uranium concentrations of 0.00896, 0.685, 0.00963, and 99.3 wt%, and specific activities of 6.22E09, 2.16E06, 6.34E07, and 3.36E05 pCi/g for U-234, U-235, U-236, and U-238, respectively.

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TABLE I.6-10

ESTIMATED CHEMICAL CONCENTRATIONS (mg/kg) IN SURFACE SOIL/COVER SOIL

Chemical	OU2 Active Flyash Residual: Exposed Soil	OU2 Inactive Flyash Residual: Exposed Soil	OU2 South Field Residual Exposed Soil	OU4 Residual: Exposed Soil
2-Methylnaphthalene	ND	ND	ND	NC
4,4-DDE	NC	NC	NC	NC
Antimony	ND	ND	ND	3.07×10^{1} [b]
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	ND	ND	ND	3.00×10^{-2} [c]
Aroclor-1260	ND	ND	ND	NC
Arsenic	1.91×10^{1} [a]	5.80×10^{0} [a]	7.03×10^{0} [a]	8.00×10^{0} [b]
Barium	ND	ND	ND	8.69×10^{1} [b]
Berylium	2.57×10^{0} [a]	1.11×10^{0} [a]	4.47×10^{-1} [a]	9.07×10^{-1} [b]
Boron	NC	ND	ND	NC
Cadmium	ND	ND	ND	5.82×10^{0} [b]
Carbazole	NC	ND	ND	NC
Chromium	ND	ND	1.36×10^{1} [a]	2.84×10^{1} [b]
Cobalt	ND	ND	ND	1.33×10^{1} [b]
Copper	ND	ND	ND	2.38×10^{1} [b]
Cyanide	ND	ND	ND	1.98×10^{0} [c]
Endrin	NC	ND	ND	NC
Lead	ND	ND	ND	1.49×10^{1} [b]
Manganese	ND	ND	ND	7.32×10^{2} [b]
Mercury	ND	ND	ND	1.20×10^{-1} [c]
Molybdenum	ND	ND	ND	1.33×10^{1} [b]
Nickel	ND	ND	ND	3.38×10^{1} [b]
Selenium	ND	ND	ND	5.70×10^{0} [c]
Silver	NC	ND	ND	1.44×10^{1} [b]
2,3,7,8-TCDD	NC	ND	ND	NC
Thallium	ND	ND	ND	7.10×10^{-1} [c]
Thorium (Total)	ND	ND	ND	2.85×10^{1} [c]
Uranium (Total)	5.67×10^{0} [a]	5.29×10^{0} [a]	1.40×10^{1} [a]	7.53×10^{1} [c]
Vanadium	ND	ND	ND	2.84×10^{1} [b]
Zinc	ND	ND	ND	5.96×10^{1} [b]

NC - Not characterized
ND = Not detected
See footnotes at end of table.

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TABLE I.6-10
(Continued)

Chemical	OU5 Residual Surface Soil [d] in Area 560a	OU5 Residual: Surface Soil [d] in Area 560b	OU5 Residual: Surface Soil [d] in Area 560c	OU5 Residual: Surface Soil [d] in Area 570a	OU5 Residual: Surface Soil in Area 570b
2-Methylnaphthalene	NC	NC	NC	NC	NC
4,4-DDE	2.00×10^{-2}	NC	NC	NC	NC
Antimony	3.20×10^{0}	2.64×10^{1}	2.52×10^{1}	1.82×10^{1}	7.60×10^{-1}
Aroclor-1221	NC	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC	NC
Aroclor-1254	NC	4.50×10^{-2}	1.30×10^{-1}	1.40×10^{-2}	NC
Aroclor-1260	NC	NC	NC	NC	NC
Arsenic	4.70×10^{0}	7.67×10^{0}	7.28×10^{0}	8.30×10^{0}	3.70×10^{0}
Barium	9.15×10^{1}	8.75×10^{1}	1.03×10^{2}	8.86×10^{1}	1.09×10^{2}
Berylium	6.90×10^{-1}	6.50×10^{-1}	1.00×10^{0}	8.90×10^{-1}	6.00×10^{-1}
Boron	1.37×10^{1}	1.37×10^{1}	6.55×10^{2}	1.37×10^{1}	1.37×10^{1}
Cadmium	5.80×10^{0}	5.00×10^{0}	4.91×10^{0}	3.81×10^{0}	5.20×10^{-1}
Carbazole	NC	NC	NC	NC	NC
Chromium	1.65×10^{1}	1.57×10^{1}	2.26×10^{1}	1.70×10^{1}	1.13×10^{1}
Cobalt	1.36×10^{1}	1.05×10^{1}	1.39×10^{1}	1.12×10^{1}	8.00×10^{0}
Copper	1.60×10^{1}	1.79×10^{1}	2.81×10^{1}	2.08×10^{1}	1.17×10^{1}
Cyanide	2.80×10^{-1}	6.80×10^{-1}	2.10×10^{-1}	1.70×10^{-1}	4.40×10^{-1}
Endrin	NC	NC	1.06×10^{-1}	NC	NC
Lead	1.92×10^{1}	3.50×10^{1}	4.94×10^{1}	2.38×10^{1}	2.38×10^{1}
Manganese	1.19×10^{3}	7.85×10^{2}	5.93×10^{2}	6.09×10^{2}	1.17×10^{3}
Mercury	3.00×10^{-1}	1.50×10^{-1}	1.60×10^{-1}	7.00×10^{-2}	3.00×10^{-1}
Molybdenum	9.20×10^{0}	2.40×10^{0}	3.90×10^{0}	3.80×10^{0}	2.70×10^{0}
Nickel	2.42×10^{1}	2.52×10^{1}	3.23×10^{1}	2.62×10^{1}	1.07×10^{1}
Selenium	7.10×10^{-1}	6.20×10^{-1}	4.87×10^{-1}	1.20×10^{0}	1.20×10^{0}
Silver	1.04×10^{1}	7.20×10^{0}	8.06×10^{0}	7.70×10^{0}	$4.70 \times 10^{0-1}$
2,3,7,8-TCDD	NC	NC	NC	NC	NC
Thallium	6.70×10^{-1}	5.80×10^{-1}	2.40×10^{-1}	3.00×10^{-1}	5.80×10^{-1}
Thorium (Total)	9.00×10^{0}	9.09×10^{0}	1.04×10^{2}	7.82×10^{0}	4.73×10^{1}
Uranium (Total)	1.43×10^{1}	6.02×10^{1}	1.17×10^{3}	2.18×10^{1}	6.19×10^{1}
Vanadium	2.51×10^{1}	2.61×10^{1}	2.88×10^{1}	2.92×10^{1}	2.31×10^{1}
Zinc	5.39×10^{1}	8.37×10^{1}	6.73×10^{1}	6.38×10^{1}	4.29×10^{1}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-10
(Continued)

Chemical	OU5 Residual Surface Soil [d] in Area 570c	OU5 Residual: Surface Soil [d] in Area 570d	OU5 Residual: Surface Soil [d] in Area 570e	OU5 Residual: Surface Soil [d] in Area 575a
2-Methylnaphthalene	3.20×10^{-1}	NC	NC	NC
4,4-DDE	NC	NC	NC	NC
Antimony	2.64×10^{1}	2.64×10^{1}	7.60×10^{-1}	7.60×10^{-1}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	1.90×10^{0}	3.80×10^{-2}	NC	NC
Aroclor-1260	2.10×10^{0}	NC	NC	NC
Arsenic	6.59×10^{0}	6.59×10^{0}	3.70×10^{0}	5.20×10^{0}
Barium	1.01×10^{2}	1.01×10^{2}	1.09×10^{2}	1.08×10^{2}
Berylium	1.10×10^{0}	1.10×10^{0}	6.00×10^{-1}	6.00×10^{-1}
Boron	6.55×10^{2}	6.55×10^{2}	1.37×10^{1}	1.37×10^{1}
Cadmium	4.70×10^{0}	4.70×10^{0}	5.20×10^{-1}	5.20×10^{-1}
Carbazole	7.70×10^{-1}	7.70×10^{-1}	NC	NC
Chromium	2.20×10^{1}	2.20×10^{1}	1.13×10^{1}	1.40×10^{1}
Cobalt	1.47×10^{1}	1.47×10^{1}	8.00×10^{0}	1.15×10^{1}
Copper	2.76×10^{1}	2.76×10^{1}	1.17×10^{1}	1.43×10^{1}
Cyanide	5.00×10^{-1}	5.00×10^{-1}	4.40×10^{-1}	3.70×10^{-1}
Endrin	NC	NC	NC	NC
Lead	4.05×10^{1}	4.05×10^{1}	2.38×10^{1}	1.99×10^{1}
Manganese	7.42×10^{2}	7.42×10^{2}	1.17×10^{3}	1.65×10^{3}
Mercury	3.00×10^{-1}	3.00×10^{-1}	3.00×10^{-1}	3.00×10^{-1}
Molybdenum	3.50×10^{0}	3.50×10^{0}	2.70×10^{0}	2.70×10^{0}
Nickel	3.17×10^{1}	3.17×10^{1}	1.07×10^{1}	1.61×10^{1}
Selenium	7.20×10^{-1}	7.20×10^{-1}	1.20×10^{0}	7.20×10^{-1}
Silver	8.45×10^{0}	8.45×10^{0}	4.70×10^{-1}	4.50×10^{-1}
2,3,7,8-TCDD	NC	NC	NC	NC
Thallium	4.30×10^{-1}	4.30×10^{-1}	5.80×10^{-1}	5.80×10^{-1}
Thorium (Total)	7.27×10^{0}	1.15×10^{2}	4.73×10^{1}	7.27×10^{0}
Uranium (Total)	3.63×10^{1}	3.52×10^{2}	6.19×10^{1}	7.53×10^{0}
Vanadium	2.79×10^{1}	2.79×10^{1}	2.31×10^{1}	2.69×10^{1}
Zinc	5.79×10^{1}	5.79×10^{1}	4.29×10^{1}	5.16×10^{1}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-10
(Continued)

Chemical	OU5 Residual: Surface Soil [d] in Area 575b	OU5 Residual: Surface Soil [d] in Area 580a	OU5 Residual: Surface Soil in Area 581a	OU5 Residual Surface Soil [d] in Area 581b
2-Methylnaphthalene	NC	NC	NC	NC
4,4-DDE	NC	NC	NC	NC
Antimony	7.60×10^{-1}	7.60×10^{-1}	2.80×10^{0}	2.90×10^{0}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	NC	NC	2.10×10^{-1}	1.20×10^{-1}
Aroclor-1260	NC	NC	NC	NC
Arsenic	3.70×10^{0}	6.50×10^{0}	5.60×10^{-1}	6.29×10^{0}
Barium	1.09×10^{2}	7.66×10^{1}	1.22×10^{2}	1.27×10^{2}
Berylium	6.00×10^{-1}	6.00×10^{-1}	6.00×10^{-1}	1.14×10^{0}
Boron	1.37×10^{1}	1.37×10^{1}	1.37×10^{1}	1.37×10^{1}
Cadmium	5.20×10^{-1}	1.30×10^{0}	5.20×10^{-1}	1.66×10^{0}
Carbazole	NC	NC	NC	NC
Chromium	1.13×10^{1}	1.13×10^{1}	1.47×10^{1}	1.63×10^{1}
Cobalt	8.00×10^{0}	5.80×10^{0}	1.13×10^{1}	2.07×10^{1}
Copper	1.17×10^{1}	1.44×10^{1}	3.10×10^{1}	1.44×10^{1}
Cyanide	4.40×10^{-1}	1.50×10^{-1}	2.80×10^{-1}	8.80×10^{-1}
Endrin	NC	NC	NC	NC
Lead	2.38×10^{1}	5.48×10^{1}	2.38×10^{1}	2.83×10^{1}
Manganese	1.17×10^{3}	4.43×10^{2}	9.79×10^{2}	2.15×10^{3}
Mercury	3.00×10^{-1}	3.00×10^{-1}	1.70×10^{-1}	3.00×10^{-1}
Molybdenum	2.70×10^{0}	2.70×10^{0}	6.26×10^{0}	7.90×10^{0}
Nickel	1.07×10^{1}	1.31×10^{1}	1.38×10^{1}	2.71×10^{1}
Selenium	1.20×10^{0}	5.30×10^{-1}	4.10×10^{-1}	5.50×10^{-1}
Silver	4.70×10^{-1}	4.50×10^{-1}	3.65×10^{0}	4.80×10^{-1}
2,3,7,8-TCDD	NC	NC	NC	NC
Thallium	5.80×10^{-1}	5.80×10^{-1}	5.79×10^{-1}	5.80×10^{-1}
Thorium (Total)	6.36×10^{0}	7.27×10^{0}	8.97×10^{0}	1.09×10^{1}
Uranium (Total)	1.73×10^{1}	6.66×10^{0}	1.75×10^{1}	7.12×10^{1}
Vanadium	2.31×10^{1}	2.25×10^{1}	2.75×10^{1}	3.48×10^{1}
Zinc	4.29×10^{1}	4.29×10^{1}	9.39×10^{1}	6.43×10^{1}

NC - Not characterized
ND = Not detected
See footnotes at end of table. 000195

TABLE I.6-10
(Continued)

Chemical	OU5 Residual: Surface Soil [d] in Area 582a	OU5 Residual: Surface Soil [d] in Area 582b	OU5 Residual: Surface Soil [d] in Area PAa	OU5 Residual: Surface Soil [d] in Area PAb
2-Methylnaphthalene	NC	NC	NC	5.16×10^{-1}
4,4-DDE	NC	NC	NC	NC
Antimony	7.60×10^{-1}	2.10×10^{0}	2.52×10^{1}	1.09×10^{1}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	NC	8.90×10^{-2}	1.30×10^{-1}	2.30×10^{0}
Aroclor-1260	NC	5.20×10^{-2}	NC	1.30×10^{0}
Arsenic	9.20×10^{0}	8.98×10^{1}	7.28×10^{0}	1.78×10^{1}
Barium	8.32×10^{1}	2.54×10^{2}	1.03×10^{2}	1.34×10^{2}
Berylium	6.00×10^{-1}	4.70×10^{0}	1.00×10^{0}	1.09×10^{0}
Boron	1.37×10^{1}	1.37×10^{1}	6.55×10^{2}	6.55×10^{2}
Cadmium	5.20×10^{-1}	5.20×10^{-1}	4.91×10^{0}	4.84×10^{0}
Carbazole	NC	2.61×10^{-1}	NC	NC
Chromium	1.59×10^{1}	1.33×10^{1}	2.26×10^{1}	2.38×10^{1}
Cobalt	1.14×10^{1}	1.15×10^{1}	1.39×10^{1}	1.18×10^{1}
Copper	1.80×10^{1}	7.38×10^{1}	2.81×10^{1}	2.83×10^{1}
Cyanide	1.50×10^{-1}	3.00×10^{-1}	2.10×10^{-1}	1.55×10^{-1}
Endrin	NC	NC	1.06×10^{1}	NC
Lead	2.81×10^{1}	5.54×10^{1}	4.94×10^{1}	9.75×10^{1}
Manganese	6.53×10^{2}	6.09×10^{2}	5.93×10^{2}	8.53×10^{2}
Mercury	1.00×10^{-1}	7.00×10^{-2}	1.60×10^{-1}	1.81×10^{-1}
Molybdenum	6.50×10^{0}	8.60×10^{0}	3.90×10^{0}	4.04×10^{0}
Nickel	2.10×10^{1}	4.01×10^{1}	3.23×10^{1}	3.50×10^{1}
Selenium	7.20×10^{-1}	5.90×10^{0}	4.87×10^{-1}	1.51×10^{0}
Silver	7.20×10^{-1}	5.12×10^{0}	8.06×10^{0}	6.00×10^{0}
2,3,7,8-TCDD	NC	NC	NC	5.60×10^{-6}
Thallium	5.80×10^{-1}	2.70×10^{0}	2.40×10^{-1}	2.63×10^{-1}
Thorium (Total)	1.36×10^{1}	2.45×10^{1}	1.55×10^{1}	1.82×10^{1}
Uranium (Total)	2.09×10^{1}	1.09×10^{1}	9.28×10^{1}	2.23×10^{2}
Vanadium	2.75×10^{1}	5.02×10^{1}	2.88×10^{1}	2.77×10^{1}
Zinc	5.52×10^{1}	7.83×10^{0}	6.73×10^{1}	1.73×10^{2}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-10
(Continued)

Chemical	OU5 Residual: Surface Soil [d] in Area PAc	OU5 Residual: Surface Soil in Area PAd	OU5 Residual Surface Soil [d] in Area PAe	OU5 Residual: Surface Soil [d] in Area PAf
2-Methyltaphthalene	NC	NC	NC	NC
4,4-DDE	NC	NC	NC	NC
Antimony	1.57×10^{1}	7.60×10^{-1}	1.93×10^{1}	7.60×10^{-1}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	1.40×10^{1}	NC	3.90×10^{-2}	NC
Aroclor-1260	NC	NC	1.40×10^{-1}	NC
Arsenic	7.79×10^{0}	7.70×10^{-1}	6.50×10^{0}	7.70×10^{-1}
Barium	1.25×10^{2}	1.87×10^{1}	1.00×10^{2}	1.87×10^{1}
Berylium	2.08×10^{0}	3.50×10^{0}	1.69×10^{0}	3.50×10^{0}
Boron	6.55×10^{2}	6.55×10^{2}	6.55×10^{2}	6.55×10^{2}
Cadmium	5.93×10^{0}	5.20×10^{-1}	4.59×10^{0}	5.20×10^{-1}
Carbazole	NC	7.40×10^{-2}	5.70×10^{-1}	7.40×10^{-2}
Chromium	4.48×10^{1}	3.60×10^{0}	2.69×10^{1}	3.60×10^{0}
Cobalt	1.94×10^{1}	1.10×10^{1}	1.09×10^{1}	1.10×10^{1}
Copper	3.26×10^{1}	5.00×10^{0}	2.38×10^{1}	5.00×10^{0}
Cyanide	1.50×10^{-1}	1.50×10^{-1}	1.20×10^{0}	1.50×10^{-1}
Endrin	NC	NC	NC	NC
Lead	2.39×10^{1}	3.70×10^{0}	8.96×10^{1}	3.70×10^{0}
Manganese	6.67×10^{2}	3.87×10^{2}	6.84×10^{2}	3.87×10^{2}
Mercury	1.40×10^{-1}	3.00×10^{-1}	3.70×10^{-1}	3.00×10^{-1}
Molybdenum	1.31×10^{1}	2.70×10^{0}	5.78×10^{0}	2.70×10^{0}
Nickel	3.32×10^{1}	5.40×10^{0}	2.58×10^{1}	5.40×10^{0}
Selenium	6.40×10^{-1}	7.20×10^{-1}	6.79×10^{-1}	7.20×10^{-1}
Silver	1.72×10^{1}	4.50×10^{-1}	5.10×10^{0}	4.50×10^{-1}
2,3,7,8-TCDD	NC	NC	NC	NC
Thallium	2.90×10^{-1}	5.80×10^{-1}	2.30×10^{-1}	5.80×10^{-1}
Thorium (Total)	2.05×10^{1}	1.35×10^{1}	3.24×10^{2}	4.55×10^{1}
Uranium (Total)	1.17×10^{3}	4.25×10^{2}	1.68×10^{4}	4.08×10^{2}
Vanadium	2.83×10^{1}	1.11×10^{1}	2.87×10^{1}	1.11×10^{1}
Zinc	1.28×10^{2}	2.58×10^{1}	1.31×10^{2}	2.58×10^{1}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-10
(Continued)

Chemical	OU5 Residual: Surface Soil [d] in Area PAg	OU5 Residual: Surface Soil [d] in Area PAh	OU5 Residual: Surface Soil [d] in Area PAi	OU5 Residual: Surface Soil [d] in Area WPAa
2-Methylnaphthalene	NC	3.20×10^{-1}	NC	NC
4,4-DDE	NC	NC	3.80×10^{-2}	1.80×10^{-2}
Antimony	7.60×10^{-1}	7.92×10^{0}	7.60×10^{-1}	2.80×10^{1}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	2.40×10^{0}	1.90×10^{0}	NC	NC
Aroclor-1260	1.00×10^{0}	2.10×10^{0}	NC	NC
Arsenic	1.26×10^{1}	6.39×10^{0}	6.40×10^{0}	6.66×10^{0}
Barium	4.10×10^{2}	7.90×10^{1}	1.83×10^{2}	6.72×10^{1}
Berylium	1.35×10^{0}	1.00×10^{0}	1.80×10^{0}	8.50×10^{-1}
Boron	6.55×10^{2}	6.55×10^{2}	1.37×10^{1}	1.43×10^{1}
Cadmium	4.90×10^{0}	4.30×10^{0}	5.20×10^{-1}	5.30×10^{0}
Carbazole	7.40×10^{-2}	7.70×10^{-1}	NC	NC
Chromium	2.40×10^{1}	1.86×10^{1}	1.97×10^{1}	1.57×10^{1}
Cobalt	1.48×10^{1}	1.07×10^{1}	1.18×10^{1}	1.06×10^{1}
Copper	2.89×10^{1}	1.94×10^{1}	1.96×10^{1}	2.10×10^{1}
Cyanide	5.20×10^{-1}	1.40×10^{-1}	1.50×10^{-1}	1.20×10^{-1}
Endrin	NC	NC	NC	NC
Lead	1.17×10^{2}	1.90×10^{1}	5.48×10^{1}	2.71×10^{1}
Manganese	9.10×10^{2}	5.55×10^{2}	1.72×10^{3}	6.55×10^{2}
Mercury	1.10×10^{0}	1.20×10^{-1}	3.00×10^{-1}	3.00×10^{-1}
Molybdenum	4.70×10^{0}	3.67×10^{0}	2.70×10^{0}	3.90×10^{0}
Nickel	3.73×10^{1}	2.98×10^{1}	3.37×10^{1}	2.66×10^{1}
Selenium	3.10×10^{0}	2.80×10^{-1}	5.30×10^{-1}	6.00×10^{-1}
Silver	3.20×10^{0}	2.70×10^{0}	4.50×10^{-1}	8.70×10^{0}
2,3,7,8-TCDD	NC	NC	NC	NC
Thallium	2.90×10^{-1}	3.40×10^{-1}	3.00×10^{-1}	6.80×10^{-1}
Thorium (Total)	2.57×10^{3}	1.00×10^{1}	7.82×10^{0}	1.00×10^{1}
Uranium (Total)	4.35×10^{4}	2.02×10^{2}	2.52×10^{1}	2.96×10^{1}
Vanadium	3.33×10^{1}	2.37×10^{1}	2.39×10^{1}	2.42×10^{1}
Zinc	3.52×10^{2}	5.33×10^{1}	7.76×10^{1}	5.88×10^{1}

NC = Not characterized
ND = Not detected

[a]From OU2 Till and GMA Concentrations (ALL_SUM.WK1), March 1994.
[b]From OU4 FS Report (Berm, Surface or Subsurface Soil) (DOE 1993h)
[c]From OU4 RI Report (Berms and/or Surface Soil) (DOE 1993d)
[d]From OU5 Statistical Analysis of FEMP Surface Soil, January 1994

For COCs which did not exceed the cleanup level, the UCL contaminant concentration in a given area or operable unit was used for that area or operable unit. This approach assumed that FEMP contamination after remediation will not be worse than currently measured levels. This approach is also extremely conservative, because no credit was taken for the effect of soil treatment, and the highest values used would not typically represent the average concentration for the modeled sources.

I.6.2.4.2 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 1985d). The EPA methodology assumes that a minimum wind speed is required for the suspension of respirable dust, and 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), crustiness of the surface soil, and the amount of vegetative cover affect the quantity of soil that can be resuspended by the wind.

The areas of the site assumed to have relatively shallow excavation include:

- Operable Unit 1 - surface soil outside of the waste pits
- Operable Unit 4 - approximately 6 to 12 inches of surface soil removed
- Operable Unit 5 - hot spot excavation.

For these areas, the existing surface soil modal diameter was used to estimate particulate matter emission rates. The PRA for Operable Unit 2 includes excavating the Active Flyash Pile, Inactive Flyash Pile, and South Field down to the upper GMA or lower glacial till layer. These layers are expected to have larger modal diameters than the existing surface soil. Therefore, these Operable Unit 2 subunits were assumed to have a limited erosion potential for particulate matter emissions.

Operable Units 1, 4, and 5

The modal diameter of FEMP surface soil was estimated from relatively coarse particle size distributions for clay, silt, sand, and gravel (Mulder 1993, ORNL 1992a) and from particle size analyses of Operable Unit 2 surface and subsurface soil (DOE 1994a). From the data in these reports, the modal diameter occurs in the silt fraction, which is between 0.002 and 0.075 millimeters (or 0.00008 and 0.003 inches).

The typical 50 percent particle size diameter (D50) is approximately 0.0206 millimeter (0.0008 inches) for surface soil (Mulder 1993). Modal diameters for surface soil in the Solid-Waste Landfill and South Field are also approximately 0.021 millimeter. Assuming that the surface soil modal diameter is 0.021 millimeter, the TFV can be determined from the EPA guidance document (Figure 3-4 in EPA 1985d). The relationship between the modal diameter and the TFV can be represented by the equation:

$$\log (TFV) = 1.812 + 0.4161 \log (d_p) \qquad (9)$$

where

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

The calculated TFV is approximately 12.9 cm/s (5 in./s) based on a modal diameter of 0.0206 millimeters (0.0008 inches). The calculated TFV should be corrected based on the surface roughness, crustiness, 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 1985d). For this CRARE, no correction was applied to the calculated TFV based on the assumption that the exposed surface would behave like 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 less than the 75 cm/s (30 in./s); therefore, the FEMP surface soil was considered to have an "unlimited" erosion potential (EPA 1985d). The equation for respirable particulate emissions of soils with unlimited erosion potential takes the following form:

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

$$E_{10} = 0.036 \times (1-V) \times [(u/u_t)^3] \times F(y) \qquad (10)$$

where

E_{10}	=	annual average PM_{10} emission rate per unit area of contaminated surface ($g/hr/m^2$),
PM_{10}	=	particulate matter with a diameter $\leq$ 10 micrometers,
V	=	fraction of soil covered by vegetation,
u	=	mean annual wind speed (m/s),
u_t	=	TFV at the height of "u" (m/s),
y	=	$0.886 \times u_t / u$,
F(y)	=	1.91 for $y < 0.5$,
F(y)	=	$0.18 \times (y^3 + 12y) \times EXP(-y^2)$ for $y > 2$, and
F(y)	=	See Figure 4-3 in EPA 1985b, for $0.5 < y < 2$.

Currently, Operable Unit 4 is 80 to 85 percent covered with vegetation. After remediation, the FEMP will be planted with appropriate vegetation for emission control and aesthetics. The region easily supports plant life, and a 100 percent vegetative cover is expected over the postremediated site, with or without continued maintenance. For this air transport analysis, 85 percent of the site was assumed to be covered with vegetation. The 85 percent value is in line with EPA estimates of control efficiencies for vegetative covers (EPA 1987a).

The TFV must be corrected to the anemometer height, 10 meters (33 feet), used to collect site wind speed data. The corrected TFV is calculated from the following equation (EPA 1985d):

$$u_t/TFV = (1/0.4) \ln (Z/Z_o) \qquad (11)$$

where

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

The surface at the FEMP will be covered with grass and other vegetation after completion of remedial actions. Using an approximated value of 0.03 meters (0.1 feet) for grassland (EPA 1985d) as Z_o, the value of u_t was calculated to be 1.89 m/s (6.2 ft/s).

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The methodology used to calculate the emissions for soil with unlimited erosion potential is based on multiplying the emission rate for a single mean annual wind speed value by an estimated annual wind speed probability distribution. This method allows for rapid calculation of annual PM_{10} emissions knowing only the mean annual wind speed. The highest annual average wind speed from the on-site meteorological data set was 2.28 m/s (DOE 1993d). Using this value in Equation 11 provides an estimated PM_{10} emission flux of 4.78×10^{-6} g/sec/m^2.

Operable Unit 2

The sand and gravel present in the exposed GMA and lower till layers in Operable Unit 2 (after remediation) are expected to have much higher modal diameter than the existing surface soil. Therefore, the limited erosion potential equation, presented below, was used to estimate particulate emissions for Operable Unit 2 subunits.

$$E_{10} = 0.83 \times f \times P(u^+) \times (1 - V) / (PE/50)^2 \qquad (12)$$

where

E_{10}	=	annual average PM_{10} emission rate per unit area of contaminated surface (g/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	=	Thornwaite's Precipitation Index (a measure of average soil moisture content).

The erosion potential in Equation 13 depends on the fastest mile, as follows (EPA 1985d):

$$P(u^+) = 6.7 \times (u^+ - u_t), \text{ for } u^+ \geq u_t, \qquad (13)$$
$$= 0, \text{ for } u^+ < u_t.$$

A typical fastest mile for the region is 24 m/s (EPA 1985d) at 7 meters above ground. Correcting the TFV previously determined for the unlimited erosion potential to 7 meters above the ground (using Equation 12) results in a value of 1.77 m/s for u_t. The calculated value for $P(u^+)$ is 148.93 g/m^2.

Since the remediated site under scenarios other than the on-property farmer will be infrequently disturbed, the value of f was assumed to be 1. Thornwait's Precipitation Index (PE) for the southwest corner of Ohio is 103 (EPA 1985d).

Currently, the FEMP is 80 to 85 percent covered with vegetation. After remediation, the South Field will be planted with vegetation appropriate for erosion control and aesthetics. The region easily supports plant life, and a 100-percent vegetative cover is expected over the postremediated 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 limited erosion potential of PM_{10} for Operable Unit 2 was calculated to be 1.21×10^{-6} g/s/m^2.

Note that the ISCLT2 model calculates dispersion for six wind speed categories (EPA 1992e). The use of a single emission rate for dispersion under all six wind speed categories will overestimate the concentrations for low wind speeds and underestimate concentrations at high wind speeds. The frequency of wind speeds in the lower-speed categories is much greater than the frequency of wind speeds in the upper-speed categories. Therefore, using a single emission rate for all wind speed categories in ISCLT2 will tend to overestimate the ground level PM_{10} concentrations. Evidence indicates (EPA 1985d) that no substantial fugitive particulate emissions occur for wind speeds less than 5 m/s (16.4 ft/s or 12 mph). These wind speeds include the lower three wind speed categories analyzed by ISCLT2.

Particulate matter radionuclide emissions for each source group are presented in Table I.6-11, and chemical emissions are presented in Table I.6-12.

TABLE I.6-11

ESTIMATED RADIONUCLIDE EMISSION FLUXES (pCi/s/m^2) FROM SURFACE SOIL/COVER SOIL[a]

Radionuclide	OU2 Active Flyash Residual: Exposed Soil	OU2 Inactive Flyash Residual: Exposed Soil	OU2 South Field Residual Exposed Soil	OU4 Residual: Exposed Soil
Cs-137	NC	ND	ND	1.12×10^{-6}
Np-237	2.20×10^{-6}	2.08×10^{-7}	3.47×10^{-6}	NC
Pa-231	NC	NC	NC	6.67×10^{-5}
Pb-210	ND	ND	ND	9.55×10^{-5}
Pu-238	ND	ND	ND	NC
Pu-239	ND	ND	ND	NC
Pu-240	ND	ND	ND	NC
Ra-226	1.16×10^{-6}	1.12×10^{-6}	1.08×10^{-6}	9.74×10^{-6}
Ra-228	9.41×10^{-7}	7.35×10^{-7}	9.47×10^{-7}	9.74×10^{-6}
Ru-106	NC	ND	ND	NC
Sr-90	ND	ND	ND	8.77×10^{-6}
Tc-99	ND	ND	ND	1.75×10^{-5}
Th-228	1.88×10^{-6}	6.95×10^{-7}	7.78×10^{-7}	9.40×10^{-6}
Th-230	2.72×10^{-6}	2.26×10^{-6}	1.47×10^{-6}	2.44×10^{-5}
Th-232	1.36×10^{-6}	6.11×10^{-7}	7.20×10^{-7}	2.44×10^{-5}
U-234	1.18×10^{-6}	1.16×10^{-6}	2.74×10^{-6}	1.69×10^{-4}
U-235	2.72×10^{-8}	8.36×10^{-8}	1.62×10^{-7}	4.49×10^{-6}
U-236	2.72×10^{-8}	8.36×10^{-8}	1.62×10^{-7}	1.85×10^{-6}
U-238	1.15×10^{-6}	1.46×10^{-6}	3.5×10^{-6}	1.01×10^{-4}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-11
(Continued)

Radionuclide	OU5 Residual: Surface Soil in Area 560a	OU5 Residual: Surface Soil in Area 560b	OU5 Residual: Surface Soil in Area 560c	OU5 Residual: Surface Soil in Area 570a
Cs-137	3.17×10^{-6}	4.87×10^{-6}	4.87×10^{-6}	2.92×10^{-6}
Np-237	NC	NC	NC	NC
Pa-231	NC	NC	NC	NC
Pb-210	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}
Pu-238	NC	NC	1.07×10^{-5}	NC
Pu-239	NC	NC	1.41×10^{-5}	NC
Pu-240	NC	NC	5.14×10^{-5}	NC
Ra-226	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Ra-228	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}
Ru-106	NC	NC	NC	NC
Sr-90	2.92×10^{-6}	1.12×10^{-5}	NC	8.77×10^{-6}
Tc-99	2.19×10^{-6}	5.11×10^{-5}	8.96×10^{-5}	3.41×10^{-6}
Th-228	1.95×10^{-6}	1.95×10^{-5}	1.95×10^{-6}	1.95×10^{-6}
Th-230	8.52×10^{-6}	1.22×10^{-5}	2.44×10^{-5}	1.07×10^{-5}
Th-232	4.82×10^{-6}	4.87×10^{-6}	2.44×10^{-5}	4.19×10^{-6}
U-234	2.03×10^{-5}	1.67×10^{-4}	4.88×10^{-4}	2.83×10^{-5}
U-235	1.46×10^{-6}	4.87×10^{-6}	1.30×10^{-5}	5.36×10^{-6}
U-236	4.29×10^{-5}	4.38×10^{-5}	5.35×10^{-6}	4.38×10^{-5}
U-238	2.29×10^{-5}	9.69×10^{-5}	2.92×10^{-4}	3.39×10^{-5}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

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TABLE I.6-11
(Continued)

Radionuclide	OU5 Residual: Surface Soil in Area 570b	OU5 Residual Surface Soil in Area 570c	OU5 Residual: Surface Soil in Area 570d	OU5 Residual: Surface Soil in Area 570e
Cs-137	4.88×10^{-6}	2.44×10^{-6}	4.87×10^{-6}	4.48×10^{-6}
Np-237	NC	NC	NC	NC
Pa-231	NC	NC	NC	NC
Pb-210	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}
Pu-238	NC	NC	4.38×10^{-1}	NC
Pu-239	NC	NC	NC	NC
Pu-240	NC	NC	NC	NC
Ra-226	1.95×10^{-6}	1.92×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Ra-228	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}
Ru-106	NC	NC	NC	NC
Sr-90	5.36×10^{-6}	3.41×10^{-6}	1.19×10^{-6}	5.36×10^{-6}
Tc-99	NC	NC	8.28×10^{-6}	NC
Th-228	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Th-230	2.44×10^{-5}	7.31×10^{-6}	2.44×10^{-5}	2.44×10^{-5}
Th-232	2.44×10^{-5}	3.90×10^{-6}	2.44×10^{-5}	2.44×10^{-5}
U-234	9.98×10^{-5}	5.75×10^{-5}	4.88×10^{-4}	9.98×10^{-5}
U-235	6.87×10^{-6}	4.38×10^{-6}	1.30×10^{-5}	6.87×10^{-6}
U-236	4.38×10^{-5}	4.38×10^{-5}	5.35×10^{-6}	4.38×10^{-5}
U-238	9.91×10^{-5}	5.80×10^{-5}	2.92×10^{-4}	9.91×10^{-5}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-11
(Continued)

Radionuclide	OU5 Residual: Surface Soil in Area 575a	OU5 Residual: Surface Soil in Area 575b	OU5 Residual: Surface Soil in Area 580a	OU5 Residual: Surface Soil in Area 581a
Cs-137	2.92×10^{-6}	4.87×10^{-6}	2.63×10^{-6}	2.21×10^{-6}
Np-237	NC	NC	NC	9.84×10^{-7}
Pa-231	NC	NC	NC	NC
Pb-210	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}
Pu-238	NC	NC	NC	NC
Pu-239	NC	NC	NC	NC
Pu-240	NC	NC	NC	NC
Ra-226	1.95×10^{-6}	1.95×10^{-6}	1.46×10^{-6}	1.95×10^{-6}
Ra-228	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}
Ru-106	NC	NC	2.53×10^{-6}	NC
Sr-90	NC	NC	NC	4.87×10^{-6}
Tc-99	9.74×10^{-7}	9.74×10^{-7}	NC	2.58×10^{-5}
Th-228	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Th-230	8.77×10^{-6}	8.28×10^{-6}	$5.84 \times 10^{0-6}$	9.50×10^{-6}
Th-232	3.90×10^{-6}	3.41×10^{-6}	3.90×10^{-6}	4.81×10^{-6}
U-234	9.25×10^{-6}	2.63×10^{-5}	6.33×10^{-6}	2.87×10^{-5}
U-235	4.87×10^{-7}	4.28×10^{-7}	6.87×10^{-6}	2.92×10^{-6}
U-236	1.43×10^{-5}	1.26×10^{-5}	4.38×10^{-5}	4.38×10^{-5}
U-238	1.22×10^{-5}	2.82×10^{-5}	8.77×10^{-6}	2.78×10^{-5}

000207

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-11
(Continued)

Radionuclide	OU5 Residual Surface Soil in Area 581b	OU5 Residual: Surface Soil in Area 582a	OU5 Residual: Surface Soil in Area 582b	OU5 Residual: Surface Soil in Area PAa
Cs-137	4.87×10^{-6}	3.90×10^{-6}	4.87×10^{-6}	2.57×10^{-6}
Np-237	NC	NC	2.44×10^{-5}	7.59×10^{-5}
Pa-231	NC	NC	NC	NC
Pb-210	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-5}	4.88×10^{-6}
Pu-238	4.14×10^{-6}	2.92×10^{-6}	3.41×10^{-6}	4.87×10^{-7}
Pu-239	NC	NC	1.47×10^{-6}	NC
Pu-240	NC	NC	5.35×10^{-6}	NC
Ra-226	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Ra-228	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}
Ru-106	NC	NC	NC	NC
Sr-90	8.18×10^{-6}	5.84×10^{-6}	2.19×10^{-5}	4.19×10^{-6}
Tc-99	3.65×10^{-6}	1.95×10^{-6}	6.91×10^{-4}	4.87×10^{-6}
Th-228	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Th-230	1.36×10^{-5}	2.44×10^{-5}	1.81×10^{-5}	2.44×10^{-5}
Th-232	5.84×10^{-6}	7.31×10^{-6}	1.31×10^{-5}	8.28×10^{-6}
U-234	1.09×10^{-4}	2.26×10^{-5}	1.75×10^{-5}	3.64×10^{-3}
U-235	6.82×10^{-6}	4.87×10^{-7}	9.74×10^{-7}	1.80×10^{-5}
U-236	4.38×10^{-5}	1.43×10^{-5}	2.86×10^{-5}	4.38×10^{-5}
U-238	1.14×10^{-4}	3.41×10^{-5}	1.75×10^{-5}	1.46×10^{-4}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-11
(Continued)

Radionuclide	OU5 Residual: Surface Soil in Area PAb	OU5 Residual: Surface Soil in Area PAc	OU5 Residual: Surface Soil in Area PAd	OU5 Residual Surface Soil in Area PAe
Cs-137	2.28×10^{-6}	9.74×10^{-7}	3.73×10^{-6}	2.28×10^{-6}
Np-237	NC	1.28×10^{-5}	NC	3.46×10^{-6}
Pa-231	NC	NC	NC	NC
Pb-210	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}
Pu-238	NC	3.50×10^{-6}	NC	NC
Pu-239	NC	3.09×10^{-6}	NC	7.35×10^{-6}
Pu-240	NC	1.12×10^{-5}	NC	2.68×10^{-5}
Ra-226	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Ra-228	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}
Ru-106	NC	NC	NC	NC
Sr-90	1.02×10^{-5}	4.09×10^{-6}	3.14×10^{-6}	2.95×10^{-5}
Tc-99	1.89×10^{-5}	1.33×10^{-5}	NC	1.17×10^{-5}
Th-228	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Th-230	2.44×10^{-5}	2.44×10^{-5}	7.29×10^{-6}	2.44×10^{-5}
Th-232	9.74×10^{-6}	1.10×10^{-5}	7.21×10^{-6}	2.44×10^{-5}
U-234	4.88×10^{-4}	4.88×10^{-4}	4.88×10^{-4}	4.88×10^{-4}
U-235	1.30×10^{-5}	1.30×10^{-5}	1.30×10^{-5}	1.30×10^{-5}
U-236	5.35×10^{-6}	5.35×10^{-6}	5.35×10^{-6}	5.35×10^{-6}
U-238	2.92×10^{-4}	2.92×10^{-4}	2.92×10^{-4}	2.92×10^{-4}

000209

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-11
(Continued)

Radionuclide	OU5 Residual: Surface Soil in Area PAf	OU5 Residual: Surface Soil in Area PAg	OU5 Residual: Surface Soil in Area PAh	OU5 Residual: Surface Soil in Area PAi	OU5 Residual: Surface Soil in Area WPAa
Cs-137	3.73×10^{-6}	4.87×10^{-6}	1.95×10^{-6}	2.63×10^{-6}	9.74×10^{-7}
Np-237	NC	NC	1.31×10^{-6}	NC	NC
Pa-231	NC	NC	NC	NC	NC
Pb-210	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}	4.88×10^{-6}	1.94×10^{-5}
Pu-238	8.28×10^{-6}	1.95×10^{-4}	1.46×10^{-7}	NC	NC
Pu-239	5.36×10^{-6}	2.58×10^{-5}	9.74×10^{-8}	NC	NC
Pu-240	1.95×10^{-5}	9.39×10^{-5}	3.54×10^{-7}	NC	NC
Ra-226	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Ra-228	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}	3.41×10^{-6}
Ru-106	NC	NC	4.43×10^{-6}	2.53×10^{-6}	NC
Sr-90	3.41×10^{-6}	3.90×10^{-6}	2.92×10^{-6}	NC	2.92×10^{-6}
Tc-99	8.77×10^{-6}	1.56×10^{-3}	4.87×10^{-6}	NC	2.19×10^{-6}
Th-228	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}	1.95×10^{-6}
Th-230	2.44×10^{-5}	2.44×10^{-5}	1.51×10^{-5}	1.09×10^{-5}	2.44×10^{-5}
Th-232	2.43×10^{-5}	2.44×10^{-5}	5.36×10^{-6}	4.19×10^{-6}	5.36×10^{-6}
U-234	4.88×10^{-4}	4.88×10^{-4}	4.88×10^{-4}	5.94×10^{-6}	1.90×10^{-5}
U-235	1.30×10^{-5}	1.30×10^{-5}	1.30×10^{-5}	4.38×10^{-5}	3.90×10^{-6}
U-236	5.35×10^{-6}	5.35×10^{-6}	5.35×10^{-6}	4.38×10^{-5}	4.38×10^{-5}
U-238	2.92×10^{-4}	2.92×10^{-4}	2.92×10^{-4}	8.77×10^{-6}	4.72×10^{-5}

NC = Not characterized
ND = Not detected

[a]Based on an annual average PM_{10} emission flux of 1.21×10^{-6} g/s/m^2 and the COC concentration in exposed soil for Operable Unit 2. For all other operable units, the PM_{10} emission flux was 4.9×10^{-6} g/s/m^2.

TABLE I.6-12

ESTIMATED CHEMICAL FLUXES ($\mu g/s/m^2$) IN SURFACE SOIL/COVER SOIL[a]

Chemical	OU2 Active Flyash Residual: Exposed Soil	OU2 Inactive Flyash Residual: Exposed Soil	OU2 South Field Residual Exposed Soil	OU4 Residual: Exposed Soil
2-Methylnaphthalene	ND	ND	ND	NC
4,4-DDE	NC	NC	NC	NC
Antimony	ND	ND	ND	1.50×10^{-4}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	ND	ND	ND	1.46×10^{-7}
Aroclor-1260	ND	ND	ND	NC
Arsenic	2.32×10^{-5}	7.02×10^{-6}	8.5×10^{-6}	3.90×10^{-5}
Barium	ND	ND	ND	4.23×10^{-6}
Berylium	3.10×10^{-6}	1.35×10^{-6}	5.41×10^{-7}	4.42×10^{-6}
Boron	NC	ND	ND	NC
Cadmium	ND	ND	ND	2.83×10^{-5}
Carbazole	NC	ND	ND	NC
Chromium	ND	ND	1.64×10^{-5}	1.38×10^{-4}
Cobalt	ND	ND	ND	6.48×10^{-5}
Copper	ND	ND	ND	1.16×10^{-4}
Cyanide	ND	ND	ND	9.64×10^{-6}
Endrin	NC	ND	ND	NC
Lead	ND	ND	ND	7.26×10^{-5}
Manganese	ND	ND	ND	3.56×10^{-3}
Mercury	ND	ND	ND	5.84×10^{-7}
Molybdenum	ND	ND	ND	6.48×10^{-5}
Nickel	ND	ND	ND	1.65×10^{-4}
Selenium	ND	ND	ND	2.78×10^{-5}
Silver	NC	ND	ND	7.01×10^{-5}
2,3,7,8-TCDD	NC	ND	ND	NC
Thallium	ND	ND	ND	3.46×10^{-6}
Thorium (Total)	ND	ND	ND	1.39×10^{-4}
Uranium (Total)	6.86×10^{-6}	6.40×10^{-6}	1.70×10^{-5}	3.67×10^{-4}
Vanadium	ND	ND	ND	1.38×10^{-4}
Zinc	ND	ND	ND	2.90×10^{-4}

000211

NC - Not characterized
ND = Not detected
See footnotes at end of table.

5506

TABLE I.6-12
(Continued)

Chemical	OU5 Residual: Surface Soil in Area 560a	OU5 Residual: Surface Soil in Area 560b	OU5 Residual: Surface Soil in Area 560c	OU5 Residual: Surface Soil in Area 570a
2-Methylnaphthalene	NC	NC	NC	NC
4,4-DDE	9.74×10^{-8}	NC	NC	NC
Antimony	1.56×10^{-5}	1.29×10^{-4}	1.23×10^{-4}	8.86×10^{-5}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	NC	2.19×10^{-7}	6.33×10^{-7}	6.28×10^{-8}
Aroclor-1260	NC	NC	NC	NC
Arsenic	2.29×10^{-5}	3.74×10^{-5}	3.55×10^{-5}	4.04×10^{-5}
Barium	4.46×10^{-4}	4.26×10^{-4}	5.02×10^{-4}	4.31×10^{-4}
Berylium	3.36×10^{-6}	3.17×10^{-6}	4.87×10^{-6}	4.33×10^{-6}
Boron	6.67×10^{-5}	6.67×10^{-5}	3.19×10^{-3}	6.67×10^{-5}
Cadmium	2.82×10^{-5}	2.44×10^{-5}	2.39×10^{-5}	1.86×10^{-5}
Carbazole	NC	NC	NC	NC
Chromium	8.04×10^{-5}	7.63×10^{-5}	1.10×10^{-4}	8.28×10^{-5}
Cobalt	6.62×10^{-5}	5.13×10^{-5}	6.77×10^{-5}	5.47×10^{-5}
Copper	7.79×10^{-5}	8.72×10^{-5}	1.37×10^{-4}	1.01×10^{-4}
Cyanide	1.36×10^{-6}	3.31×10^{-6}	1.02×10^{-6}	8.28×10^{-7}
Endrin	NC	NC	5.16×10^{-7}	NC
Lead	9.35×10^{-5}	1.70×10^{-4}	2.41×10^{-4}	1.16×10^{-4}
Manganese	5.77×10^{-3}	3.82×10^{-3}	2.89×10^{-3}	2.97×10^{-3}
Mercury	1.46×10^{-6}	7.31×10^{-7}	7.79×10^{-7}	3.41×10^{-7}
Molybdenum	4.48×10^{-5}	1.17×10^{-5}	1.90×10^{-5}	1.85×10^{-5}
Nickel	1.18×10^{-4}	1.23×10^{-4}	1.57×10^{-4}	1.28×10^{-4}
Selenium	3.46×10^{-6}	3.02×10^{-6}	2.37×10^{-6}	5.84×10^{-6}
Silver	5.06×10^{-5}	3.51×10^{-5}	3.93×10^{-5}	3.75×10^{-5}
2,3,7,8-TCDD	NC	NC	NC	NC
Thallium	3.26×10^{-6}	2.82×10^{-61}	1.17×10^{-6}	1.46×10^{-6}
Thorium (Total)	4.38×10^{-5}	4.43×10^{-5}	5.05×10^{-4}	3.81×10^{-5}
Uranium (Total)	6.95×10^{-5}	2.93×10^{-4}	5.69×10^{-3}	1.06×10^{-4}
Vanadium	1.22×10^{-4}	1.27×10^{-4}	1.40×10^{-4}	1.42×10^{-4}
Zinc	2.62×10^{-4}	4.08×10^{-4}	3.28×10^{-4}	3.11×10^{-4}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

000212

TABLE I.6-12
(Continued)

Chemical	OU5 Residual: Surface Soil in Area 570b	OU5 Residual Surface Soil in Area 570c	OU5 Residual: Surface Soil in Area 570d	OU5 Residual: Surface Soil in Area 570e
2-Methylnaphthalene	NC	1.56×10^{-6}	NC	NC
4,4-DDE	NC	NC	NC	NC
Antimony	3.70×10^{-6}	1.29×10^{-4}	1.29×10^{-4}	3.70×10^{-6}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	NC	9.25×10^{-6}	1.85×10^{-7}	NC
Aroclor-1260	NC	1.02×10^{-5}	NC	NC
Arsenic	1.80×10^{-5}	3.21×10^{-5}	3.21×10^{-5}	1.80×10^{-5}
Barium	5.31×10^{-4}	4.91×10^{-4}	4.91×10^{-4}	5.31×10^{-4}
Berylium	2.92×10^{-6}	5.36×10^{-6}	5.36×10^{-6}	2.92×10^{-6}
Boron	6.67×10^{-5}	3.19×10^{-3}	3.19×10^{-3}	6.67×10^{-5}
Cadmium	2.53×10^{-6}	2.29×10^{-5}	2.29×10^{-5}	2.53×10^{-6}
Carbazole	NC	3.75×10^{-6}	3.75×10^{-6}	NC
Chromium	5.50×10^{-5}	1.07×10^{-4}	1.07×10^{-4}	5.50×10^{-5}
Cobalt	3.90×10^{-5}	7.16×10^{-5}	7.16×10^{-5}	3.90×10^{-5}
Copper	5.70×10^{-5}	1.34×10^{-4}	1.34×10^{-4}	5.70×10^{-5}
Cyanide	2.14×10^{-6}	2.44×10^{-6}	2.44×10^{-6}	2.14×10^{-6}
Endrin	NC	NC	NC	NC
Lead	1.16×10^{-4}	1.97×10^{-4}	1.97×10^{-4}	1.16×10^{-4}
Manganese	5.70×10^{-3}	3.61×10^{-3}	3.61×10^{-3}	5.70×10^{-3}
Mercury	1.46×10^{-6}	1.46×10^{-6}	1.46×10^{-6}	1.46×10^{-6}
Molybdenum	1.31×10^{-5}	1.70×10^{-5}	1.70×10^{-5}	1.31×10^{-5}
Nickel	5.21×10^{-5}	1.54×10^{-4}	1.54×10^{-4}	5.21×10^{-5}
Selenium	5.84×10^{-6}	3.51×10^{-6}	3.51×10^{-6}	5.84×10^{-6}
Silver	2.29×10^{-6}	4.12×10^{-5}	4.12×10^{-5}	2.29×10^{-6}
2,3,7,8-TCDD	NC	NC	NC	NC
Thallium	2.82×10^{-6}	2.09×10^{-6}	2.09×10^{-6}	2.82×10^{-6}
Thorium (Total)	2.30×10^{-4}	3.54×10^{-5}	5.62×10^{-4}	2.30×10^{-4}
Uranium (Total)	3.01×10^{-4}	1.77×10^{-4}	1.72×10^{-3}	3.01×10^{-4}
Vanadium	1.12×10^{-4}	1.36×10^{-4}	1.36×10^{-4}	1.12×10^{-4}
Zinc	2.09×10^{-4}	2.82×10^{-4}	2.82×10^{-4}	2.09×10^{-4}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

000213

TABLE I.6-12
(Continued)

Chemical	OU5 Residual: Surface Soil in Area 575a	OU5 Residual: Surface Soil in Area 575b	OU5 Residual: Surface Soil in Area 580a	OU5 Residual: Surface Soil in Area 581a
2-Methylnaphthalene	NC	NC	NC	NC
4,4-DDE	NC	NC	NC	NC
Antimony	3.70×10^{-6}	3.70×10^{-6}	3.70×10^{-6}	1.36×10^{-5}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	NC	NC	NC	1.02×10^{-6}
Aroclor-1260	NC	NC	NC	NC
Arsenic	2.53×10^{-5}	1.80×10^{-5}	3.17×10^{-5}	2.73×10^{-6}
Barium	5.26×10^{-4}	5.31×10^{-4}	3.73×10^{-4}	5.93×10^{-4}
Berylium	2.92×10^{-6}	2.92×10^{-6}	2.92×10^{-6}	2.92×10^{-6}
Boron	6.67×10^{-5}	6.67×10^{-5}	6.67×10^{-5}	6.67×10^{-5}
Cadmium	2.53×10^{-6}	2.53×10^{-6}	6.33×10^{-6}	2.53×10^{-6}
Carbazole	NC	NC	NC	NC
Chromium	6.82×10^{-5}	5.50×10^{-5}	5.50×10^{-5}	7.17×10^{-5}
Cobalt	5.60×10^{-5}	3.90×10^{-5}	2.82×10^{-5}	5.50×10^{-5}
Copper	6.96×10^{-5}	5.70×10^{-5}	7.01×10^{-5}	1.51×10^{-4}
Cyanide	1.80×10^{-6}	2.14×10^{-6}	7.31×10^{-7}	1.36×10^{-6}
Endrin	NC	NC	NC	NC
Lead	9.69×10^{-5}	1.16×10^{-4}	2.67×10^{-4}	1.16×10^{-4}
Manganese	8.04×10^{-3}	5.70×10^{-3}	2.16×10^{-3}	4.77×10^{-3}
Mercury	1.46×10^{-6}	1.46×10^{-6}	1.46×10^{-6}	8.28×10^{-7}
Molybdenum	1.31×10^{-5}	1.31×10^{-5}	1.31×10^{-5}	3.05×10^{-5}
Nickel	7.84×10^{-5}	5.21×10^{-5}	6.38×10^{-5}	6.72×10^{-5}
Selenium	3.51×10^{-6}	5.84×10^{-6}	2.58×10^{-6}	2.00×10^{-6}
Silver	2.19×10^{-6}	2.29×10^{-6}	2.19×10^{-6}	1.78×10^{-5}
2,3,7,8-TCDD	NC	NC	NC	NC
Thallium	2.82×10^{-6}	2.82×10^{-6}	2.82×10^{-6}	2.82×10^{-6}
Thorium (Total)	3.54×10^{-5}	3.10×10^{-5}	3.54×10^{-5}	4.37×10^{-5}
Uranium (Total)	3.67×10^{-5}	8.45×10^{-5}	3.24×10^{-5}	8.53×10^{-5}
Vanadium	1.31×10^{-4}	1.12×10^{-4}	1.10×10^{-4}	1.34×10^{-4}
Zinc	2.51×10^{-4}	2.09×10^{-4}	2.09×10^{-4}	4.57×10^{-4}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

TABLE I.6-12
(Continued)

Chemical	OU5 Residual Surface Soil in Area 581b	OU5 Residual: Surface Soil in Area 582a	OU5 Residual: Surface Soil in Area 582b	OU5 Residual: Surface Soil in Area PAa
2-Methylnaphthalene	NC	NC	NC	NC
4,4-DDE	NC	NC	NC	NC
Antimony	1.41×10^{-5}	3.70×10^{-6}	1.02×10^{-5}	1.23×10^{-4}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	5.84×10^{-7}	NC	4.33×10^{-7}	6.33×10^{-7}
Aroclor-1260	NC	NC	2.53×10^{-7}	NC
Arsenic	3.06×10^{-5}	4.48×10^{-5}	4.37×10^{-4}	3.55×10^{-5}
Barium	6.18×10^{-4}	4.05×10^{-4}	1.24×10^{-3}	5.02×10^{-4}
Berylium	5.55×10^{-6}	2.92×10^{-6}	2.29×10^{-5}	4.87×10^{-6}
Boron	6.67×10^{-5}	6.67×10^{-5}	6.67×10^{-5}	3.19×10^{-3}
Cadmium	8.08×10^{-6}	2.53×10^{-6}	2.53×10^{-6}	2.39×10^{-5}
Carbazole	NC	NC	1.27×10^{-6}	NC
Chromium	7.93×10^{-5}	7.74×10^{-5}	6.48×10^{-5}	1.10×10^{-4}
Cobalt	1.01×10^{-4}	5.55×10^{-5}	5.60×10^{-5}	6.77×10^{-5}
Copper	7.01×10^{-5}	8.77×10^{-5}	3.59×10^{-4}	1.37×10^{-4}
Cyanide	4.29×10^{-6}	7.31×10^{-7}	1.46×10^{-6}	1.02×10^{-6}
Endrin	NC	NC	NC	5.16×10^{-7}
Lead	1.38×10^{-4}	1.37×10^{-4}	2.70×10^{-4}	2.41×10^{-4}
Manganese	1.05×10^{-2}	3.18×10^{-3}	2.97×10^{-3}	2.89×10^{-3}
Mercury	1.46×10^{-6}	4.87×10^{-7}	3.41×10^{-7}	1.90×10^{-5}
Molybdenum	3.85×10^{-5}	3.17×10^{-5}	4.19×10^{-5}	1.90×10^{-5}
Nickel	1.32×10^{-4}	1.02×10^{-4}	1.95×10^{-4}	1.57×10^{-4}
Selenium	2.68×10^{-6}	3.51×10^{-6}	2.49×10^{-5}	3.93×10^{-5}
Silver	2.34×10^{-6}	3.51×10^{-6}	2.49×10^{-5}	3.93×10^{-5}
2,3,7,8-TCDD	NC	NC	NC	NC
Thallium	2.82×10^{-6}	2.82×10^{-6}	1.31×10^{-5}	1.17×10^{-6}
Thorium (Total)	5.31×10^{-5}	6.64×10^{-5}	1.19×10^{-4}	7.53×10^{-5}
Uranium (Total)	3.47×10^{-4}	1.02×10^{-4}	5.30×10^{-5}	4.52×10^{-4}
Vanadium	1.69×10^{-4}	1.34×10^{-4}	2.44×10^{-4}	1.40×10^{-4}
Zinc	3.13×10^{-4}	2.69×10^{-4}	3.81×10^{-5}	3.28×10^{-4}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

5508

TABLE I.6-12
(Continued)

Chemical	OU5 Residual: Surface Soil in Area PAb	OU5 Residual: Surface Soil in Area PAc	OU5 Residual: Surface Soil in Area PAd	OU5 Residual Surface Soil in Area PAe
2-Methylnaphthalene	2.51×10^{-6}	NC	NC	NC
4,4-DDE	NC	NC	NC	NC
Antimony	5.32×10^{-5}	7.65×10^{-5}	3.70×10^{-6}	9.40×10^{-5}
Aroclor-1221	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC
Aroclor-1254	1.12×10^{-5}	6.82×10^{-5}	NC	1.90×10^{-7}
Aroclor-1260	6.33×10^{-6}	NC	NC	6.82×10^{-7}
Arsenic	8.65×10^{-5}	3.79×10^{-5}	3.75×10^{-6}	3.17×10^{-5}
Barium	6.53×10^{-4}	6.07×10^{-4}	9.11×10^{-5}	4.87×10^{-4}
Berylium	5.31×10^{-6}	1.01×10^{-5}	1.70×10^{-5}	8.23×10^{-6}
Boron	3.19×10^{-3}	3.19×10^{-3}	3.19×10^{-3}	3.19×10^{-3}
Cadmium	2.36×10^{-5}	2.89×10^{-5}	2.53×10^{-6}	2.24×10^{-5}
Carbazole	NC	NC	3.60×10^{-7}	2.78×10^{-6}
Chromium	1.16×10^{-4}	2.18×10^{-4}	1.75×10^{-5}	1.31×10^{-4}
Cobalt	5.74×10^{-5}	9.42×10^{-5}	5.34×10^{-5}	5.29×10^{-5}
Copper	1.38×10^{-4}	1.59×10^{-4}	2.44×10^{-5}	1.16×10^{-4}
Cyanide	7.55×10^{-7}	7.31×10^{-7}	7.31×10^{-7}	5.84×10^{-6}
Endrin	NC	NC	NC	NC
Lead	4.75×10^{-4}	1.16×10^{-4}	1.80×10^{-5}	4.36×10^{-4}
Manganese	4.15×10^{-3}	3.25×10^{-3}	1.88×10^{-3}	3.33×10^{-3}
Mercury	1.97×10^{-5}	6.82×10^{-7}	1.46×10^{-6}	1.80×10^{-6}
Molybdenum	1.97×10^{-5}	6.38×10^{-5}	1.31×10^{-5}	2.81×10^{-5}
Nickel	1.70×10^{-4}	1.62×10^{-4}	2.63×10^{-5}	1.26×10^{-4}
Selenium	2.92×10^{-5}	3.12×10^{-6}	3.51×10^{-6}	3.31×10^{-6}
Silver	2.92×10^{-5}	8.38×10^{-5}	2.19×10^{-6}	2.48×10^{-5}
2,3,7,8-TCDD	2.73×10^{-11}	NC	NC	NC
Thallium	1.28×10^{-6}	1.41×10^{-6}	2.82×10^{-6}	1.12×10^{-6}
Thorium (Total)	8.85×10^{-5}	9.96×10^{-5}	6.55×10^{-5}	1.58×10^{-3}
Uranium (Total)	1.08×10^{-3}	5.71×10^{-3}	2.07×10^{-3}	8.17×10^{-2}
Vanadium	1.35×10^{-4}	1.38×10^{-4}	5.41×10^{-5}	1.40×10^{-4}
Zinc	8.40×10^{-4}	6.25×10^{-4}	1.26×10^{-4}	6.39×10^{-4}

NC - Not characterized
ND = Not detected
See footnotes at end of table.

000216

TABLE I.6-12
(Continued)

Chemical	OU5 Residual: Surface Soil in Area PAf	OU5 Residual: Surface Soil in Area PAg	OU5 Residual: Surface Soil in Area PAh	OU5 Residual: Surface Soil in Area PAi	OU5 Residual: Surface Soil in Area WPAa
2-Methylnaphthalene	NC	NC	1.56×10^{-6}	NC	NC
4,4-DDE	NC	NC	NC	1.85×10^{-7}	8.77×10^{-8}
Antimony	3.70×10^{-6}	3.70×10^{-6}	3.86×10^{-5}	3.70×10^{-6}	1.36×10^{-4}
Aroclor-1221	NC	NC	NC	NC	NC
Aroclor-1248	NC	NC	NC	NC	NC
Aroclor-1254	NC	1.17×10^{-5}	9.25×10^{-6}	NC	NC
Aroclor-1260	NC	4.87×10^{-6}	1.02×10^{-5}	NC	NC
Arsenic	3.75×10^{-6}	6.12×10^{-5}	3.11×10^{-5}	3.12×10^{-5}	3.24×10^{-5}
Barium	9.11×10^{-5}	1.99×10^{-3}	3.85×10^{-4}	8.91×10^{-4}	3.27×10^{-4}
Berylium	1.70×10^{-5}	6.59×10^{-6}	4.87×10^{-6}	8.77×10^{-6}	4.14×10^{-6}
Boron	3.19×10^{-3}	3.19×10^{-3}	3.19×10^{-3}	6.67×10^{-5}	6.96×10^{-5}
Cadmium	2.53×10^{-6}	2.39×10^{-5}	2.09×10^{-5}	2.53×10^{-6}	2.58×10^{-5}
Carbazole	3.60×10^{-7}	3.60×10^{-7}	3.75×10^{-6}	NC	NC
Chromium	1.75×10^{-5}	1.17×10^{-4}	9.06×10^{-5}	9.59×10^{-5}	7.63×10^{-5}
Cobalt	5.34×10^{-5}	7.19×10^{-5}	5.21×10^{-5}	5.75×10^{-5}	5.18×10^{-5}
Copper	2.44×10^{-5}	1.41×10^{-4}	9.45×10^{-5}	9.55×10^{-5}	1.02×10^{-4}
Cyanide	7.31×10^{-7}	2.53×10^{-6}	6.82×10^{-7}	7.31×10^{-7}	5.84×10^{-7}
Endrin	NC	NC	NC	NC	NC
Lead	1.80×10^{-5}	5.70×10^{-4}	9.25×10^{-5}	2.67×10^{-4}	1.32×10^{-4}
Manganese	1.88×10^{-3}	4.43×10^{-3}	2.70×10^{-3}	8.38×10^{-3}	3.19×10^{-3}
Mercury	1.46×10^{-6}	5.36×10^{-6}	5.84×10^{-7}	1.46×10^{-6}	1.46×10^{-6}
Molybdenum	1.31×10^{-5}	2.29×10^{-5}	1.79×10^{-5}	1.31×10^{-5}	1.90×10^{-5}
Nickel	2.63×10^{-5}	1.82×10^{-4}	1.45×10^{-4}	1.64×10^{-4}	1.30×10^{-4}
Selenium	3.51×10^{-6}	1.51×10^{-5}	1.36×10^{-6}	2.58×10^{-6}	2.92×10^{-6}
Silver	2.19×10^{-6}	1.56×10^{-5}	1.31×10^{-5}	2.19×10^{-6}	4.24×10^{-5}
2,3,7,8-TCDD	NC	NC	NC	NC	NC
Thallium	2.82×10^{-6}	1.41×10^{-6}	1.66×10^{-6}	1.46×10^{-6}	3.31×10^{-6}
Thorium (Total)	2.21×10^{-4}	1.25×10^{-2}	4.87×10^{-5}	3.81×10^{-5}	4.87×10^{-5}
Uranium (Total)	1.99×10^{-3}	2.12×10^{-1}	9.82×10^{-4}	1.23×10^{-4}	1.44×10^{-4}
Vanadium	5.41×10^{-5}	1.62×10^{-4}	1.15×10^{-4}	1.16×10^{-4}	1.18×10^{-4}
Zinc	1.26×10^{-4}	1.72×10^{-3}	2.60×10^{-4}	3.78×10^{-4}	2.86×10^{-4}

NC = Not characterized
ND = Not detected

[a]Based on an annual average PM_{10} emission flux of 1.21×10^{-6} g/s/m^2 and the COC concentration in exposed soil for Operable Unit 2. For all other operable units the PM_{10} emission flux was 4.9×10^{-6} g/s/m^2.

I.6.2.5 Gaseous Contaminant Emission Rates

Emissions of Rn-222 were estimated for all exposed soil areas. No other gaseous emissions were estimated. Volatile and semivolatile organics were assumed to have decayed to negligible levels prior to the time period studied by this analysis. Radionuclides, nonvolatile organics, and inorganics were assumed to be transported with the particulates emitted from the site.

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 are presented in the RAWPA. The Ra-226 concentrations and the Rn-222 fluxes from each emission source are presented in Table I.6-13. The RAECOM calculated emission rates are presented in Attachment I.III.

TABLE I.6-13

Rn-222 FLUXES FROM RAECOM MODEL

Emission Source	Ra-226 Concentration (pCi/g)	Rn-222 Flux (pCi/s/m^2)
OU1 Residual Soil (Area WPAa)	0.40	1.30×10^{-1}
OU2 Inactive Flyash Pile	9.24×10^{-1}	4.77×10^{-1}
OU2 Active Flyash Pile	9.56×10^{-1}	4.18×10^{-1}
OU2 South Field	8.95×10^{-1}	6.84×10^{-2}
OU4 Residual Soil	2.00	9.57×10^{-1}
OU5 Soil (All Areas Except 580a)	0.40	1.30×10^{-1}
OU5 Soil (Area 580a)	0.30	1.08×10^{-1}

I.6.2.6 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 (33 feet) 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 (180 feet) above the ground. The temperature difference was calculated from air temperature measurements taken at 60 and 10 meters (180 and 30 feet) 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 distribution of windspeed, wind direction, and atmospheric stability is presented in Attachment I.III. The composite distribution was used in the ISCLT2 dispersion model.

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

I.6.2.7 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 625 receptor points in a 121.9 x 121.9 meter (400 x 400 foot) pattern which extended over the entire FEMP property. The FEMP coordinate system was used for origin and location. The second grid consisted of 360 receptor points also in a 121.9 x 121.9 meter (400 x 400 foot) pattern located over the center of the FEMP. The second grid was offset 60 meters (200 feet) north and 60 meters (200) feet east of the first grid, resulting in an effective 86.2 x 86.2 meter (283 x 283 foot) pattern over the center of the FEMP.

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 along the centerline and halfway between Silos 1 and 2 in Operable Unit 4. The analysis results for the fenceline receptor with the highest air quality impacts are reported as the maximum off-property concentrations in Section I.6.2.10. In addition, seven discrete locations were identified to represent sensitive receptors. These locations

included: Crosby, Elda, Morgan, and St. John Elementary Schools, Ross Middle and High School, Ross County Day Nursery, and Venice Presbyterian Pre-School.

Figure I.6-23 shows the layout of the receptor grid considered in the air dispersion modeling. Because the concentrations were used primarily to estimate inhalation pathway risk for outdoor activities, the receptors were assumed to be 1.5 meters (5 feet) above the ground to simulate a typical person's breathing height for outdoor activities (EPA 1989l). The variation of ground level concentration within 0 to 1.5 meters (5 feet) is negligible.

I.6.2.8 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 circumscribed by a 3-kilometer (1.9-mile) 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 (1.9-mile) 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.

I.6.2.9 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 I.6-11 and I.6-12 to determine the contaminant-specific annual concentrations presented in Section I.6.2.10. Spreadsheets were used to calculate the contaminant-specific concentrations from the ISCLT2 model output and emissions data in Tables I.6-11 and I.6-12.

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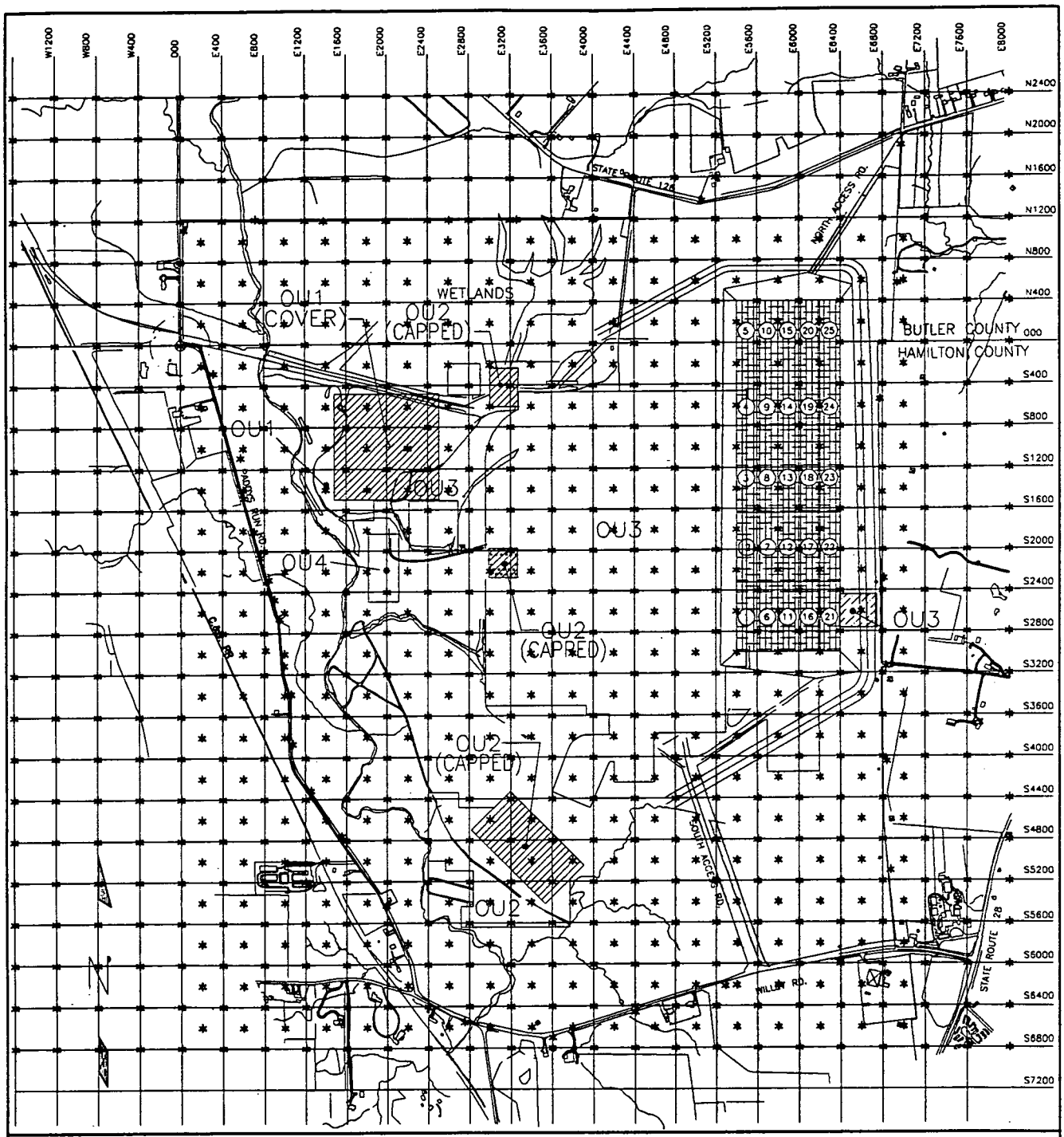

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* = RECEPTOR GRID POINT

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FIGURE 1.6-23

RECEPTOR GRIDS FOR AIR DISPERSION MODELING

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The 531 area sources were combined into 29 source groups:

1. Operable Unit 1 residual soil (Area WPAa)
2. Operable Unit 2 Inactive Flyash Pile
3. Operable Unit 2 Active Flyash Pile
4. Operable Unit 2 South Field
5. Operable Unit 4 residual soil

6-8. Operable Unit 5 surface soil (Areas 560a,b,c)

9-13. Operable Unit 5 surface soil (Areas 570a,b,c,d,e)

14-15. Operable Unit 5 surface soil (Area 575a,b)

16. Operable Unit 5 surface soil (Areas 580a)

17-18. Operable Unit 5 surface soil (Area 581a,b)

19-20. Operable Unit 5 surface soil (Area 582a,b)

21-29. Operable Unit 5 surface soil beneath former production area (Areas PAa,b,c,d,e,f,g,h,i)

I.6.2.10 Results of Air Dispersion Modeling

This section presents the modeled air concentration for each contaminant. 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.

I.6.2.10.1 Modeled Air Concentrations

The modeled maximum annual average radionuclide air concentrations are presented in Table I.6-14 and chemical concentrations in Table I.6-15. The values presented are the maximum on-property concentration, maximum off-property (fenceline) concentration, and maximum concentration at a sensitive receptor for each contaminant. 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 I.6-14

RADIONUCLIDE CONCENTRATIONS IN AIR

Radionuclide	Maximum On-Property (pCi/m^3)	Maximum Off-Property (pCi/m^3)	Maximum at Sensitive Receptors (pCi/m^3)
Cs-137	9.31×10^{-5}	4.77×10^{-5}	4.30×10^{-6}
Np-237	2.64×10^{-4}	1.95×10^{-5}	2.48×10^{-6}
Pa-231	3.00×10^{-4}	1.99×10^{-5}	6.76×10^{-7}
Pb-210	5.39×10^{-4}	8.27×10^{-5}	8.85×10^{-6}
Pu-238	4.33×10^{-4}	3.02×10^{-5}	2.10×10^{-6}
Pu-239	7.16×10^{-5}	7.59×10^{-6}	5.92×10^{-7}
Pu-240	2.60×10^{-4}	2.76×10^{-5}	2.15×10^{-6}
Ra-226	7.02×10^{-5}	3.14×10^{-5}	2.89×10^{-6}
Ra-228	1.18×10^{-4}	5.49×10^{-5}	4.97×10^{-6}
Rn-222	6.54×10^{0}	2.66×10^{0}	2.16×10^{-1}
Ru-106	4.43×10^{-5}	8.34×10^{-6}	6.61×10^{-7}
Sr-90	1.88×10^{-4}	7.97×10^{-5}	7.28×10^{-6}
Tc-99	3.43×10^{-3}	3.87×10^{-4}	2.99×10^{-5}
Th-228	9.86×10^{-5}	3.58×10^{-5}	3.35×10^{-6}
Th-230	4.24×10^{-4}	2.58×10^{-4}	1.92×10^{-5}
Th-232	2.53×10^{-4}	9.39×10^{-5}	9.66×10^{-6}
U-234	1.73×10^{-2}	2.39×10^{-3}	2.54×10^{-4}
U-235	3.77×10^{-4}	9.75×10^{-5}	8.41×10^{-6}
U-236	1.24×10^{-3}	5.76×10^{-4}	4.79×10^{-5}
U-238	5.49×10^{-3}	1.20×10^{-3}	1.20×10^{-4}

TABLE I.6-15

CHEMICAL CONCENTRATIONS IN AIR

Chemical	Maximum On-Property ($\mu g/m^3$)	Maximum Off-Property ($\mu g/m^3$)	Maximum at Sensitive Receptors ($\mu g/m^3$)
2-Methylnaphthalene	1.95×10^{-5}	3.91×10^{-6}	3.05×10^{-7}
4,4-DDE	1.33×10^{-6}	1.03×10^{-6}	5.75×10^{-8}
Antimony	1.83×10^{-3}	5.47×10^{-4}	6.19×10^{-5}
Aroclor-1221	0.00×10^{0}	0.00×10^{0}	0.00×10^{0}
Aroclor-1248	0.00×10^{0}	0.00×10^{0}	0.00×10^{0}
Aroclor-1254	3.37×10^{-4}	3.42×10^{-5}	3.08×10^{-6}
Aroclor-1260	1.06×10^{-4}	1.93×10^{-5}	1.55×10^{-6}
Arsenic	1.77×10^{-3}	5.34×10^{-4}	4.32×10^{-5}
Barium	1.91×10^{-2}	8.69×10^{-3}	6.88×10^{-4}
Beryllium	1.73×10^{-4}	5.96×10^{-5}	5.97×10^{-6}
Boron	5.79×10^{-2}	1.11×10^{-2}	9.85×10^{-4}
Cadmium	6.14×10^{-4}	3.74×10^{-4}	2.68×10^{-5}
Carbazole	4.27×10^{-5}	7.33×10^{-6}	6.11×10^{-7}
Chromium	2.55×10^{-3}	1.22×10^{-3}	1.19×10^{-4}
Cobalt	1.81×10^{-3}	9.31×10^{-4}	8.43×10^{-5}
Copper	4.60×10^{-3}	2.03×10^{-3}	1.40×10^{-4}
Cyanide	5.88×10^{-5}	2.29×10^{-5}	2.17×10^{-6}
Endrin	1.81×10^{-6}	1.47×10^{-7}	1.58×10^{-8}
Lead	4.69×10^{-3}	2.10×10^{-3}	2.04×10^{-4}
Manganese	1.51×10^{-1}	7.67×10^{-2}	6.69×10^{-3}
Mercury	1.26×10^{-4}	2.77×10^{-5}	2.93×10^{-6}
Molybdenum	9.60×10^{-4}	5.40×10^{-4}	4.15×10^{-5}
Nickel	3.30×10^{-3}	1.78×10^{-3}	1.66×10^{-4}
Selenium	2.30×10^{-4}	6.54×10^{-5}	7.13×10^{-6}
Silver	1.00×10^{-3}	6.45×10^{-4}	4.54×10^{-5}
2,3,7,8-TCDD (Equiv.)	1.43×10^{-10}	2.06×10^{-11}	1.33×10^{-12}
Thallium	1.10×10^{-4}	4.40×10^{-5}	3.82×10^{-6}
Thorium (Total)	2.86×10^{-2}	2.30×10^{-3}	2.14×10^{-4}
Uranium (Total)	4.94×10^{-1}	5.84×10^{-2}	3.81×10^{-3}
Vanadium	4.54×10^{-3}	2.11×10^{-3}	1.82×10^{-4}
Zinc	1.29×10^{-2}	6.28×10^{-3}	4.85×10^{-4}

Gaseous Rn-222 emissions resulted in the highest activity concentrations of any radionuclide analyzed by at least two orders of magnitude. The maximum on-property, fenceline, and sensitive receptor concentrations of Rn-222 were modeled at 6.54, 2.66, and 0.216 pCi/m^3, respectively. Isopleths of Rn-222 concentrations are shown on Figure I.6-24. The maximum value is between two and three orders of magnitude below the EPA action level of 4000 pCi/m^3 (4 pCi/l) for indoor radon concentrations. The maximum value is also two orders of magnitude below the annual average U.S. residential radon concentration of 1250 pCi/m^3 (Marcinowski and Napolitano 1993).

Approximately 72 percent of the modeled on-property maximum Rn-222 concentration was associated with Operable Unit 4. Operable Unit 5 amounted for 23 percent of the on-property maximum concentration; Operable Unit 1 accounted for 5 percent; and Operable Unit 2 accounted for less than 1 percent. Approximately 95 percent of the modeled off-property maximum Rn-222 concentration was associated with Operable Unit 5. Operable Unit 2 accounted for 2 percent of the off-property maximum concentration; Operable Unit 4 accounted for 2 percent; and Operable Unit 1 accounted for 1 percent.

Modeled concentrations of U-234 typically represented the next-highest radionuclide activity concentrations, after Rn-222. The maximum on-property, fenceline, and sensitive receptor concentrations of U-234 were modeled at 0.017, 0.0024, and 0.00025 pCi/m^3, respectively. Isopleths of U-234 concentrations are presented on Figure I.6-25.

Over 99 percent of the modeled U-234 concentrations were associated with Operable Unit 5. Area PAa within the former production area accounted for approximately 70 percent of the maximum on-property uranium concentrations; the surface soil on the rest of the former production area accounted for approximately 19 percent; and the surface soil on the remainder of the FEMP accounted for approximately 11 percent. The remediated soil in the former production area accounted for approximately 86 percent of the maximum fenceline concentration, and the surface soil on the remainder of the FEMP accounted for approximately 14 percent.

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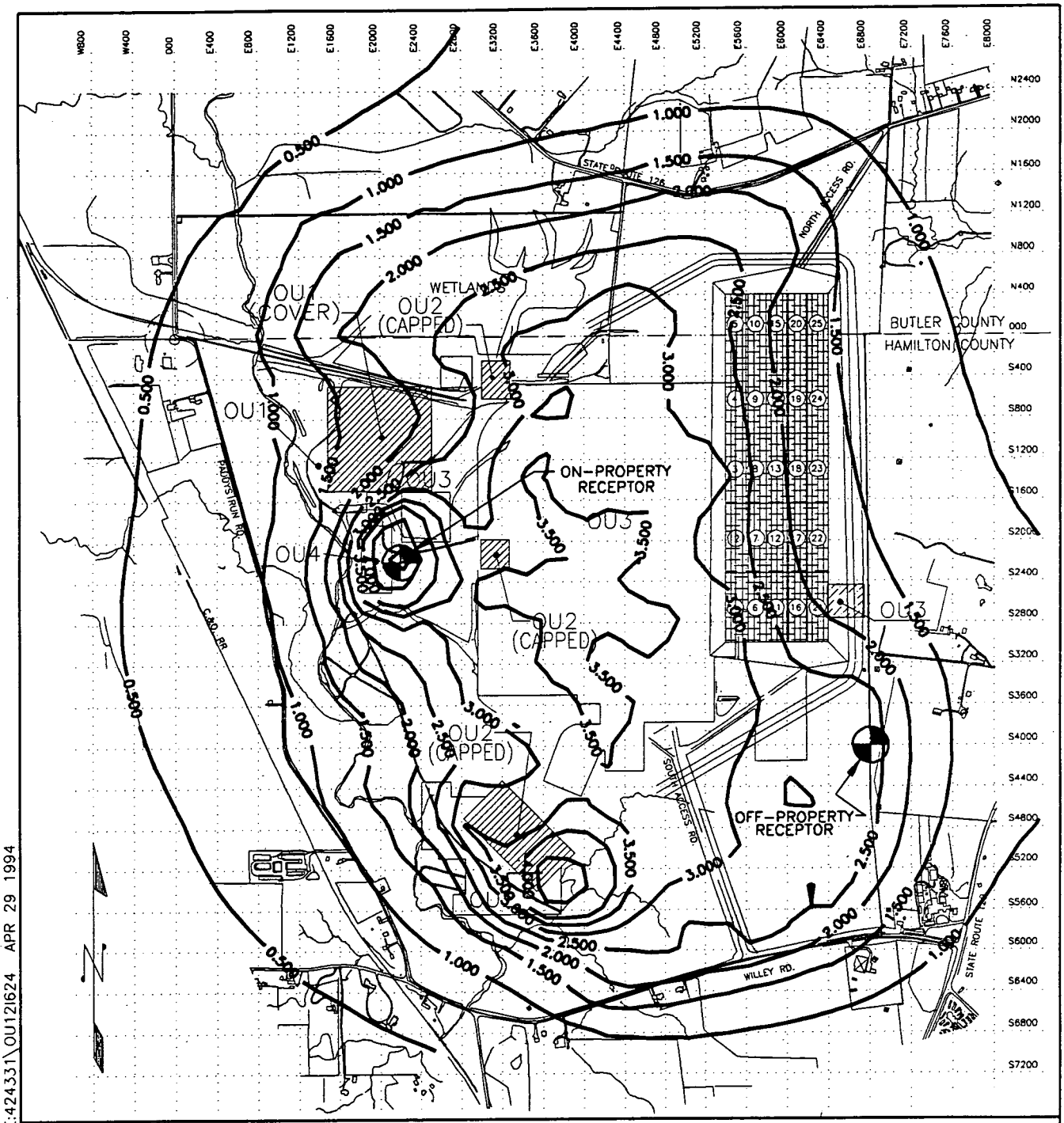

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SCALE IN FEET

RME RECEPTOR LOCATION

— 0.500 — CONCENTRATION ISOPLETHS ARE IN PICOCURIES PER CUBIC METER

MAX ON-PROPERTY CONC. = 6.54 pCi/m³

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FIGURE 1.6-24
Rn-222 CONCENTRATIONS IN AIR

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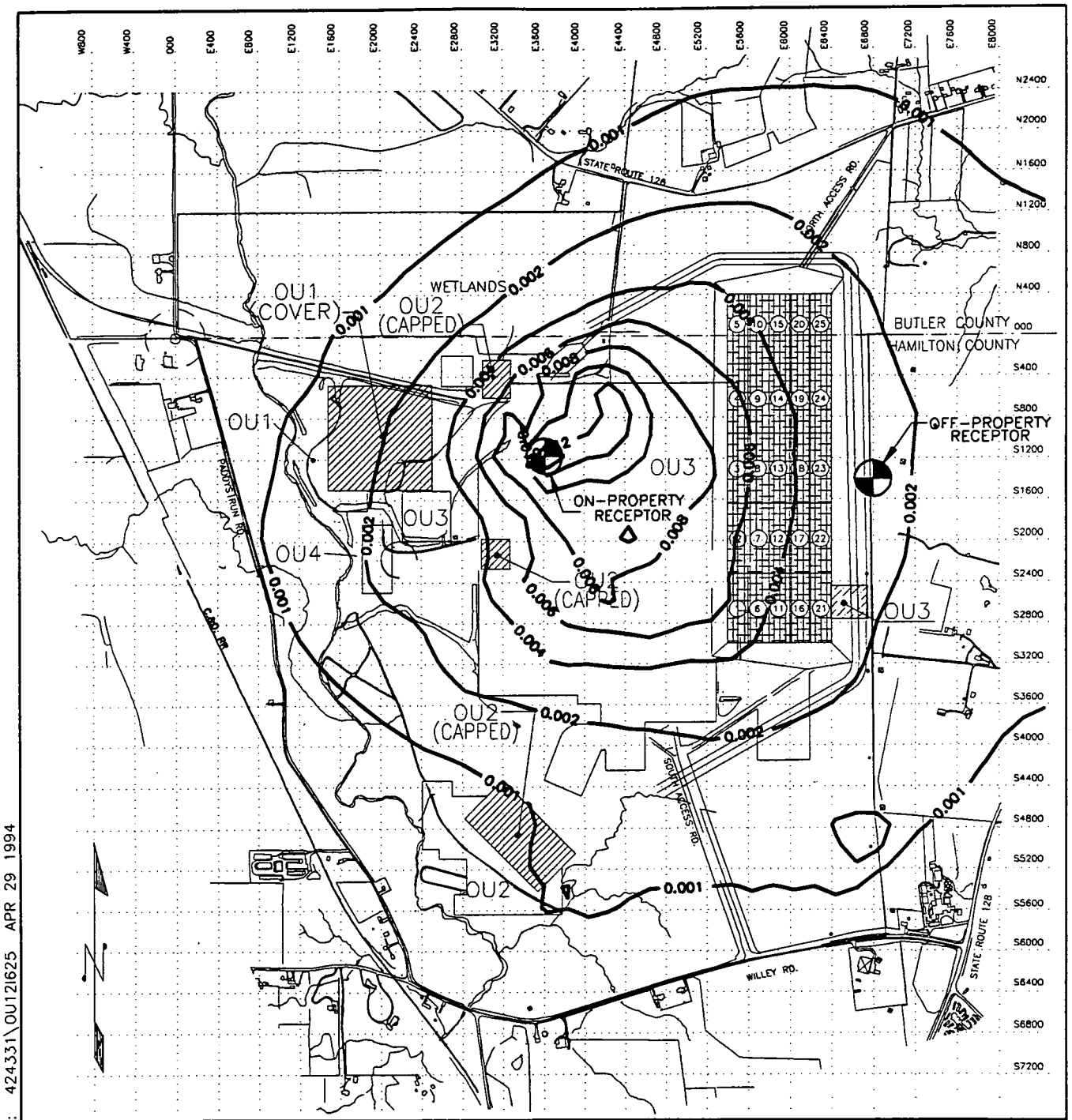

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SCALE IN FEET

RME RECEPTOR LOCATION

—0.001— : CONCENTRATION ISOPLETHS ARE IN PICOCURIES PER CUBIC METER

MAX ON-PROPERTY CONC. = 0.0173 pCi/m^3

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FIGURE 1.6-25
U-234 CONCENTRATIONS IN AIR

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I.6.2.10.2 Comparison to Monitored Air Concentrations

The average monitored fenceline concentrations of Rn-222 were approximately 240, 230, and 310 pCi/m^3 (corrected for background levels) during 1989, 1990, and 1991, respectively (DOE 1991a and 1992a). This analysis indicates that implementing the remedial alternatives would result in mitigating approximately 99 percent of existing Rn-222 emission impacts.

The maximum monitored fenceline concentration of U-234 was approximately 0.00013 pCi/m^3 during 1990 (DOE 1991a). Monitored and modeled fenceline results for several radionuclides are presented in Table I.6-16. These results indicate that the modeled concentrations are approximately one order of magnitude higher than concentrations currently monitored at the FEMP. Uncertainties in the particle size distributions, wind entrainment emission rates, and contaminant soil concentrations may account for this apparent over prediction by the model. In particular, the assumptions that no soil crust forms on the property and that no nonerodible elements exist on the FEMP served to overestimate the total particulate emissions. The vegetative cover estimate and modal diameter assumed may also have served to overestimate particulate emissions. See Sections I.10.0 and I.11.0 for additional discussion of uncertainty.

TABLE I.6-16
MODELED AND MONITORED RADIONUCLIDE FENCELINE CONCENTRATIONS IN AIR (pCi/m^3)

Radionuclide	Modeled Value	1990 Monitored Values
Cs-137	4.77×10^{-5}	$<5.9 \times 10^{-5}$
Np-237	1.95×10^{-5}	$<1.4 \times 10^{-6}$
Pu-238	3.02×10^{-5}	$<1.2 \times 10^{-6}$
Pu-239	7.59×10^{-6}	$<1.1 \times 10^{-6}$
Pu-240	2.76×10^{-5}	$<1.1 \times 10^{-6}$
Ra-226	3.14×10^{-5}	$<1.6 \times 10^{-6}$
Ra-228	5.49×10^{-5}	$<1.2 \times 10^{-5}$
Sr-90	7.97×10^{-5}	3.8×10^{-6}
Tc-99	3.87×10^{-4}	$<1.1 \times 10^{-4}$
Th-228	3.58×10^{-5}	$<5.8 \times 10^{-6}$
Th-230	2.58×10^{-4}	6.9×10^{-6}
Th-232	9.39×10^{-5}	$<5.8 \times 10^{-6}$
U-234	2.39×10^{-3}	1.3×10^{-4}
U-235	9.75×10^{-5}	4.8×10^{-6}
U-236	5.76×10^{-4}	1.7×10^{-6}
U-238	1.20×10^{-3}	1.2×10^{-4}

SOURCE: DOE 1991a

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I.6.3 FARM PRODUCTS FATE MODELING

This section describes the equations used to estimate exposure to chemicals and radionuclides from ingestion of contaminated farm products.

I.6.3.1 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 1989e). 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):

$$C_{ivw} = d_w \left[\frac{r_w (1 - e^{-\lambda_{Ei} t_o})}{Y \lambda_{Ei}} + \frac{f_w B_{iv} (1 - e^{-\lambda_{di} t_{bw}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t_h} \qquad (14)$$

For vegetation exposed to atmospheric fallout of dust, the equation becomes (NRC 1977):

$$C_{ivd} = d_d \left[\frac{r_d (1 - e^{-\lambda_{Ei} t_o})}{Y \lambda_{Ei}} + \frac{f_d B_{iv} (1 - e^{-\lambda_{di} t_{bd}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t_h} \qquad (15)$$

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}), from 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),

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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),

$$\lambda_{di} = \lambda_{ri} + \lambda_{Li} \tag{16}$$

and

$$\lambda_{Li} = \frac{V_w}{Z\theta\left[1 + \sigma\,\frac{K_d}{\theta}\right]} \tag{17}$$

$$d_w = (C_{iw})(I)) \tag{18}$$
$$d_d = (C_{id})(v_d) \tag{19}$$

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 partioning 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 I.III,
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 was used to estimate the contaminant concentration in the plant from root uptake of contaminants in the soil.

$$C_{ivs} = (C_s)(B_{iv})(e^{-\lambda_{di} t_h}) \tag{20}$$

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).

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The total concentration of contaminants in vegetables (C_{iv}) is estimated using the following equation:

$$C_{iv} = C_{ivw} + C_{ivd} + C_{ivs} \qquad (21)$$

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 I.6-17. Radioactive or chemical decay constants are presented in Table I.6-18. Transfer coefficients of contaminants from dry soil to wet plant material are presented in Table I.6-19. Source concentrations for farm product fate modeling are presented in Table I.6-20.

I.6.3.2 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):

$$C_{iA} = F_{iA}[(C_{if})(Q_f) + (C_{iAw})(Q_{Aw})]\, e^{(-\lambda_{ri} t_{iA})} \qquad (22)$$

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 I.6-19. Contaminant concentrations in forage are presented in Table I.6-21.

TABLE I.6-17

SUMMARY OF PARAMETERS FOR VEGETABLE/FORAGE UPTAKE MODELS

Parameter[a]	Value	Units	Reference
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)	MD[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})	300	hr	Assumed
Period Soil is Exposed to Airborne Emissions (t_{bd})	720	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 I.10.0) 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).

TABLE I.6-18

CHEMICAL AND RADIOACTIVE COC DECAY CONSTANTS

Chemical	Decay Constant (λ_{ri}) (hr^{-1})	Source	Radionuclide	Decay Constant (λ_{ri}) (hr^{-1})	Source
Antimony	1.00×10^{-14}	a	Cs-137	2.62×10^{-6}	b
Aroclor-1221	1.00×10^{-14}	a	Np-237	3.70×10^{-11}	b
Aroclor-1248	1.00×10^{-14}	a	Pa-231	5.80×10^{-8}	a
Aroclor-1254	1.00×10^{-14}	a	Pb-210	8.53×10^{-5}	a
Aroclor-1260	1.00×10^{-14}	a	Pu-238	9.01×10^{-7}	b
Arsenic	1.00×10^{-14}	a	Pu-239	3.28×10^{-9}	b
Barium	1.00×10^{-14}	a	Pu-240	1.20×10^{-8}	b
Beryllium	1.00×10^{-14}	a	Ra-226	9.93×10^{-4}	a
Boron	1.00×10^{-14}	a	Ra-228	9.93×10^{-4}	a
Cadmium	1.00×10^{-14}	a	Rn-222	NA	
Carbazole	1.00×10^{-14}	a	Ru-106	9.99×10^{-1}	b
Chromium	1.00×10^{-14}	a	Sr-90	1.00×10^{0}	b
Cobalt	1.00×10^{-14}	a	Tc-99	1.00×10^{0}	b
Copper	1.00×10^{-14}	a	Th-228	9.93×10^{-4}	a
Cyanide	1.00×10^{-14}	a	Th-230	2.47×10^{-8}	a
Endrin	1.00×10^{-14}	a	Th-232	1.36×10^{-13}	a
Lead	1.00×10^{-14}	a	U-234	7.77×10^{-9}	a
Manganese	1.00×10^{-14}	a	U-235	2.70×10^{-12}	a
Mercury	1.00×10^{-14}	a	U-236	3.38×10^{-12}	b
Molybdenum	1.00×10^{-14}	a	U-238	4.25×10^{-13}	a
Nickel	1.00×10^{-14}	a			
Selenium	1.00×10^{-14}	a			
Silver	1.00×10^{-14}	a			
Thallium	1.00×10^{-14}	a			
Thorium	1.00×10^{-14}	a			
Uranium	1.00×10^{-14}	a			
Vanadium	1.00×10^{-14}	a			
Zinc	1.00×10^{-14}	a			
2-Methylnaphthalene	1.00×10^{-14}	a			
4,4-DDE	1.00×10^{-14}	a			

[a]DOE (1993d)
[b]Grove Engineering (1991)
NA = Non Applicable

TABLE I.6-19

Kd AND TRANSFER COEFFICIENTS

COC	Kd(cm^3/g)	Beef $_{Fia}$	Source	Milk $_{Fia}$	Source	Vegetable B $_{(IV2)}$	Source	Forage B $_{(IV1)}$	Source
Chemical									
Antimony		1.00×10^{-3}	a	1.00×10^{-4}	c	1.28×10^{-2}	d	3.00×10^{-2}	a
Aroclor-1221		1.58×10^{-5}	b	5.01×10^{-6}	c	NA		9.32×10^{-1}	e
Aroclor-1248		1.00×10^{-2}	a	1.02×10^{-2}	c	7.88×10^{-3}	d	2.20×10^{-2}	a
Aroclor-1254		7.40×10^{-2}	a	1.60×10^{-2}	c	7.28×10^{-3}	d	7.10×10^{-3}	a
Aroclor-1260		3.20×10^{-2}	a	6.46×10^{-2}	c	4.88×10^{-3}	d	1.10×10^{-2}	a
Arsenic	2.00×10^{2}	2.00×10^{-3}	a	6.00×10^{-5}	d	2.57×10^{-3}	d	4.00×10^{-2}	a
Barium	1.14×10^{3}	1.50×10^{-4}	a	3.50×10^{-4}	d	6.42×10^{-4}	d	1.50×10^{-1}	a
Beryllium	1.30×10^{3}	1.00×10^{-3}	a	9.00×10^{-7}	d	4.28×10^{-3}	d	1.00×10^{-2}	a
Boron		1.50×10^{-4}	d	3.50×10^{-4}	d	8.56×10^{-1}	d	4.00×10^{0}	d
Cadmium	5.00×10^{2}	5.50×10^{-3}	a	1.00×10^{-3}	d	6.42×10^{-2}	d	5.50×10^{-1}	a
Carbazole	1.00×10^{-10}	NA		NA		NA		NA	
Chromium	1.50×10^{3}	5.50×10^{-3}	d	1.50×10^{-3}	d	1.93×10^{-3}	d	7.50×10^{-3}	d
Cobalt		2.00×10^{-2}	a	2.00×10^{-3}	d	3.00×10^{-3}	d	2.00×10^{-2}	a
Copper		1.00×10^{-2}	a	1.50×10^{-3}	d	1.07×10^{-1}	d	4.00×10^{-1}	a
Cyanide		5.63×10^{-8}		NA		NA		3.50×10^{-1}	a
Endrin		1.20×10^{-2}	d	1.74×10^{-3}	d	6.46×10^{-3}	d	1.51×10^{-2}	d
Lead	3.00×10^{3}	3.00×10^{-4}	a	2.50×10^{-4}	d	3.85×10^{-3}	d	4.50×10^{-2}	a
Manganese		4.00×10^{-4}	a	3.50×10^{-4}	d	2.14×10^{-2}	d	2.50×10^{-1}	a
Mercury		2.50×10^{-1}	a	4.50×10^{-4}	d	8.56×10^{-2}	d	9.00×10^{-1}	a
Molybdenum	9.00×10^{-1}	6.00×10^{-3}	a	1.50×10^{-3}	d	2.57×10^{-1}	d	6.00×10^{-2}	d
Nickel	6.50×10^{2}	6.00×10^{-3}	a	1.00×10^{-3}	d	2.57×10^{-2}	d	6.00×10^{-2}	a
Selenium		1.50×10^{-2}	a	4.00×10^{-3}	d	1.07×10^{-2}	d	2.50×10^{-2}	a

TABLE I.6-19
(Continued)

COC	Kd(cm^3/g)	Beef $_{Fia}$	Source	Milk $_{Fia}$	Source	Vegetable B $_{(IV2)}$	Source	Forage B $_{(IV1)}$	Source
Chemical (cont.)									
Silver		3.00×10^{-3}	d	2.00×10^{-2}	d	4.28×10^{-2}	d	4.00×10^{-1}	d
Tetrachlorodibenzo-p-dioxin		NA		NA		NA		NA	
Thallium		4.00×10^{-2}	a	2.00×10^{-3}	d	1.71×10^{-4}	d	4.00×10^{-3}	a
Thorium		6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-5}	d	8.50×10^{-4}	a
Uranium		2.00×10^{-4}	a	6.00×10^{-4}	d	1.71×10^{-3}	d	8.50×10^{-3}	a
Vanadium	1.00×10^{3}	2.50×10^{-3}	a	2.00×10^{-5}	d	1.28×10^{-3}	d	5.50×10^{-3}	a
Zinc	2.40×10^{3}	1.00×10^{-1}	a	1.00×10^{-2}	d	3.85×10^{-1}	d	1.50×10^{0}	a
2-Methylnaphthalene		1.82×10^{-4}	a	1.02×10^{-4}	c	NA		NA	
4,4-DDE	6.58×10^{4}	1.45×10^{-2}	a	2.40×10^{-3}	d	4.49×10^{-2}	d	1.80×10^{-2}	a
Radionuclide									
Cs-137	1.81×10^{3}	2.00×10^{-2}	a	7.00×10^{-3}	d	1.28×10^{-2}	d	8.00×10^{-2}	a
Np-237	5.50×10^{1}	5.50×10^{-5}	a	5.00×10^{-6}	d	4.28×10^{-2}	d	1.00×10^{-2}	a
Pa-231		8.00×10^{-2}	a	5.00×10^{-4}	d	1.07×10^{-4}	d	2.50×10^{-4}	a
Pb-210		NA		NA		3.85×10^{-3}		NA	
Pu-238	1.70×10^{3}	5.00×10^{-7}	a	1.00×10^{-7}	d	1.93×10^{-5}	d	4.50×10^{-4}	a
Pu-239	1.70×10^{3}	5.00×10^{-7}	a	1.00×10^{-7}	d	1.93×10^{-5}	d	4.50×10^{-4}	a
Pu-240	1.70×10^{3}	5.00×10^{-7}	a	1.00×10^{-7}	d	1.93×10^{-5}	d	4.50×10^{-4}	a
Ra-226	6.96×10^{2}	2.50×10^{-4}	a	4.50×10^{-4}	d	6.42×10^{-4}	d	1.50×10^{-2}	a
Ra-228	6.96×10^{2}	2.50×10^{-4}	a	4.50×10^{-4}	d	6.42×10^{-4}	d	1.50×10^{-2}	a
Rn-222		NA		NA		NA		NA	
Ru-106		NA		6.00×10^{-7}	d	8.56×10^{-3}	d	2.00×10^{-2}	a
Sr-90	1.18×10^{-1}	3.00×10^{-4}	a	1.50×10^{-3}	d	1.07×10^{-1}	d	2.50×10^{0}	a

TABLE I.6-19
(Continued)

COC	Kd(cm^3/g)	Beef $_{Fia}$	Source	Milk $_{Fia}$	Source	Vegetable B $_{(IV2)}$	Source	Forage B $_{(IV1)}$	Source
Radionuclide (cont.)									
Tc-99		8.50×10^{-3}	a	1.00×10^{-2}	d	6.42×10^{-1}	d	9.50×10^{0}	a
Th-228	5.80×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-5}	d	8.50×10^{-4}	d
Th-230	5.80×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-5}	d	8.50×10^{-4}	d
Th-232	3.20×10^{3}	6.00×10^{-6}	a	5.00×10^{-6}	d	3.64×10^{-5}	d	8.50×10^{-4}	d
U-234	7.50×10^{1}	2.00×10^{-4}	a	6.00×10^{-4}	d	1.71×10^{-3}	d	8.50×10^{-3}	d
U-235	7.50×10^{1}	2.00×10^{-4}	a	6.00×10^{-4}	d	1.71×10^{-3}	d	8.50×10^{-3}	d
U-236	7.50×10^{1}	2.00×10^{-4}	a	6.00×10^{-4}	d	1.71×10^{-3}	d	8.50×10^{-3}	d
U-238	7.50×10^{1}	2.00×10^{-4}	a	6.00×10^{-4}	d	1.71×10^{-3}	d	8.50×10^{-3}	d

[a]SWCR (DOE 1993e)
[b]Log of bioconcentration factor in beef (Log Bb) calculated from geometric mean regression model: Log Bb = -7.6 + Log Kow (RAWPA; DOE 1992i)
[c]Log of Biotransfer factor in milk (Log Bm) calculated from geometric mean regression model: Log Bm = -8.10 + Log Kow (RAWPA; DOE 1992i)
[d]Operable Unit 2 RI Report (DOE 1994a)
[e]Log of bioconcentration factor in vegetation (Log Bv) calculated from geometric mean regression model: Log Bv = 1.588 - 0.578 Log Kow (RAWPA; DOE 1992i)
[f]Not Available

TABLE I.6-20

SOURCE CONCENTRATIONS FOR FARM PRODUCTS FATE MODELING

Chemical	Cid (mg/g)	C_{iw} (mg/l) Current Off-Property	Future Off-Property	Future On-Property	Cs (mg/kg)
Antimony	5.47×10^{-7}	3.05×10^{-7}	6.90×10^{-8}	1.24×10^{-3}	5.35×10^{0}
Aroclor-1221	NA	2.21×10^{-34}	1.03×10^{-27}	2.29×10^{-24}	N/A
Aroclor-1248	NA	NA	NA	NA	NA
Aroclor-1254	3.42×10^{-8}	NA	NA	NA	NA
Aroclor-1260	1.93×10^{-8}	NA	NA	NA	NA
Arsenic	5.34×10^{-7}	NA	NA	NA	5.09×10^{0}
Barium	8.69×10^{-6}	NA	NA	NA	9.72×10^{1}
Beryllium	5.96×10^{-8}	NA	NA	NA	7.55×10^{-1}
Boron	1.11×10^{-5}	NA	NA	NA	1.12×10^{2}
Cadmium	3.74×10^{-7}	4.07×10^{-31}	1.71×10^{-24}	2.88×10^{-20}	3.48×10^{0}
Carbazole	7.33×10^{-9}	NA	NA	NA	NA
Chromium	1.22×10^{-6}	NA	NA	NA	1.64×10^{1}
Cobalt	9.31×10^{-7}	NA	NA	NA	1.21×10^{1}
Copper	2.03×10^{-6}	NA	NA	NA	2.02×10^{1}
Cyanide	2.29×10^{-8}	NA	NA	NA	2.50×10^{-1}
Endrin	1.47×10^{-10}	NA	NA	NA	NA
Lead	2.10×10^{-6}	NA	NA	NA	2.35×10^{1}
Manganese	7.67×10^{-5}	NA	NA	NA	9.76×10^{2}
Mercury	2.77×10^{-8}	NA	NA	NA	2.14×10^{-1}
Molybdenum	5.40×10^{-7}	NA	NA	NA	6.49×10^{0}
Nickel	1.78×10^{-6}	NA	NA	NA	2.26×10^{1}
Selenium	6.54×10^{-8}	NA	NA	NA	6.31×10^{-1}
Silver	6.45×10^{-7}	NA	NA	NA	6.03×10^{0}
Tetrachlorodibenzo-p	2.06×10^{-14}	NA	NA	NA	3.48×10^{-8}
Thallium	4.40×10^{-8}	NA	NA	NA	5.58×10^{-1}
Thorium	2.30×10^{-6}	NA	NA	NA	NA
Uranium	5.84×10^{-5}	NA	NA	NA	NA
Vanadium	2.11×10^{-6}	NA	NA	NA	2.60×10^{1}
Zinc	6.28×10^{-6}	NA	NA	NA	6.41×10^{1}
2-Methylnaphthalene	3.91×10^{-9}	NA	NA	NA	NA
4,4-DDE	1.03×10^{-9}	NA	NA	NA	NA

See footnotes at end of table.

TABLE I.6-20
(Continued)

Radionuclides	Cid (pCi/g)	C_{iw} (pCi/l) Current Off-Property	Future Off-Property	Future On-Property	Cs (pCi/kg)
Cs-137	4.77×10^{-5}	7.68×10^{-3}	8.04×10^{-2}	5.68×10^{-1}	5.85×10^{-4}
Np-237	1.95×10^{-5}	NA	NA	NA	8.36×10^{-5}
Pa-231	1.99×10^{-5}	NA	NA	NA	NA
Pb-210	8.27×10^{-5}	NA	NA	NA	1.05×10^{-3}
Pu-238	3.02×10^{-5}	NA	NA	NA	9.07×10^{-5}
Pu-239	7.59×10^{-6}	NA	NA	NA	1.25×10^{-5}
Pu-240	2.76×10^{-5}	NA	NA	NA	4.55×10^{-5}
Ra-226	3.14×10^{-5}	NA	NA	NA	3.99×10^{-4}
Ra-228	5.49×10^{-5}	NA	NA	NA	7.00×10^{-4}
Rn-222	2.66×10^{0}	NA	NA	NA	NA
Ru-106	8.34×10^{-6}	NA	NA	NA	1.33×10^{-4}
Sr-90	7.97×10^{-5}	NA	NA	NA	8.33×10^{-4}
Tc-99	3.87×10^{-4}	4.06×10^{2}	1.22×10^{3}	5.24×10^{3}	1.87×10^{-3}
Th-228	3.58×10^{-5}	NA	NA	NA	4.00×10^{-4}
Th-230	2.58×10^{-4}	NA	NA	NA	5.92×10^{-5}
Th-232	9.39×10^{-5}	NA	NA	NA	5.95×10^{-4}
U-234	2.39×10^{-3}	9.27×10^{0}	2.62×10^{1}	1.01×10^{2}	2.06×10^{-2}
U-235	9.75×10^{-5}	2.46×10^{-1}	6.96×10^{-1}	2.68×10^{0}	9.34×10^{-4}
U-236	5.76×10^{-4}	1.01×10^{-1}	2.87×10^{-1}	1.11×10^{0}	6.86×10^{-3}
U-238	1.20×10^{-3}	5.54×10^{0}	1.57×10^{1}	6.00×10^{1}	1.38×10^{-2}

NA = Not Available

000239

TABLE I.6-21

CONTAMINANT CONCENTRATION IN FORAGE

Chemical	C_{if} (mg/kg) Off-Property	On-Property
Antimony	1.14×10^{-7}	1.61×10^{-1}
Aroclor-1221	NA	NA
Aroclor-1248	NA	NA
Aroclor-1254	7.14×10^{-9}	2.33×10^{-3}
Aroclor-1260	4.03×10^{-9}	3.11×10^{-3}
Arsenic	1.13×10^{-7}	2.04×10^{-1}
Barium	1.88×10^{-6}	1.46×10^{1}
Beryllium	1.25×10^{-8}	7.55×10^{-3}
Boron	2.84×10^{-6}	4.48×10^{2}
Cadmium	8.89×10^{-8}	1.91×10^{0}
Carbazole	1.53×10^{-9}	1.53×10^{-9}
Chromium	2.55×10^{-7}	1.23×10^{-1}
Cobalt	1.95×10^{-7}	2.42×10^{-1}
Copper	4.33×10^{-7}	8.08×10^{0}
Cyanide	4.88×10^{-9}	8.75×10^{-2}
Endrin	3.07×10^{-11}	3.11×10^{-6}
Lead	4.43×10^{-7}	1.06×10^{0}
Manganese	1.62×10^{-5}	2.44×10^{2}
Mercury	6.08×10^{-9}	1.93×10^{-1}
Molybdenum	1.14×10^{-7}	3.89×10^{-1}
Nickel	3.77×10^{-7}	1.36×10^{0}
Selenium	1.37×10^{-8}	1.58×10^{-2}
Silver	1.38×10^{-7}	2.41×10^{0}
Tetrachlorodibenzo-p-dioxin	4.30×10^{-15}	4.30×10^{-15}
Thallium	9.19×10^{-9}	2.23×10^{-3}
Thorium	4.80×10^{-7}	4.80×10^{-7}
Uranium	1.22×10^{-5}	1.22×10^{-5}
Vanadium	4.41×10^{-7}	1.43×10^{-1}
Zinc	1.81×10^{-6}	9.62×10^{1}
2-Methylnaphthalene	8.16×10^{-10}	8.16×10^{-10}
4,4-DDE	2.16×10^{-10}	1.55×10^{-4}

See footnotes at end of table.

000240

TABLE I.6-21
(Continued)

Radionuclides	C_{if} (pCi/kg) Off-Property	On-Property
Cs-137	1.02×10^{-5}	4.68×10^{1}
Np-237	4.08×10^{-6}	8.36×10^{-1}
Pa-231	4.16×10^{-6}	4.16×10^{-6}
Pb-210	1.73×10^{-5}	1.73×10^{-5}
Pu-238	6.31×10^{-6}	4.08×10^{-2}
Pu-239	1.58×10^{-6}	5.63×10^{-3}
Pu-240	5.76×10^{-6}	2.05×10^{-2}
Ra-226	6.56×10^{-6}	5.99×10^{0}
Ra-228	1.15×10^{-5}	1.05×10^{-1}
Rn-222	5.55×10^{-1}	5.55×10^{-1}
Ru-106	1.74×10^{-6}	2.66×10^{0}
Sr-90	1.66×10^{-5}	2.08×10^{3}
Tc-99	8.08×10^{-5}	1.78×10^{4}
Th-228	7.48×10^{-6}	5.03×10^{-2}
Th-230	5.39×10^{-5}	5.06×10^{-1}
Th-232	1.96×10^{-5}	1.75×10^{1}
U-234	5.00×10^{-4}	$1,75 \times 10^{2}$
U-235	2.04×10^{-5}	7.94×10^{0}
U-236	1.21×10^{-4}	5.83×10^{1}
U-238	2.51×10^{-4}	1.17×10^{2}

NA = Not Available

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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 1989e):

where

$$C_{iA} = F_{iA}[(C_s)(Q_s)]e^{(-\lambda_{di} t_{iA})} \quad (24)$$

C_s = concentration ofcontaminant 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 radioelements and nonradioactive metals were taken from Baes et al. (1984), Till and Meyer (1983) and DOE (1989). 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 I.6-19. 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).

Concentrations in the aboveground vegetative part of plants were estimated using the following equation (Baes et al. 1984):

$$C_{iv} = (C_s)(B_{iv(1)}) \qquad (24)$$

where

C_{iv} = concentration of the ith contaminant in vegetation (mg/kg dry wt),
C_s = maximum concentration in soil (mg/kg dry wt), and
$B_{iv(1)}$ = soil to plant transfer factor of the ith contaminant (mg/kg dry wt plant per mg/kg dry wt soil).

I.6.3.3 Results of Farm Product Fate Modeling

Tables I.6-22 through I.6-24 present a summary of modeling results for the contaminant concentrations in vegetables, meat, and dairy products under the Current Land Use and two Future Land Use (with and without federal ownership) scenarios. These values have been incorporated into Section I.8.0.

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TABLE I.6-22

MODELED FARM PRODUCT COC CONCENTRATIONS: OFF-SITE RESIDENT FARM RECEPTORS, CURRENT LAND USE

Chemical	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/kg)	Vegetable Concentration (mg/kg)
Antimony	2.10×10^{-8}	2.40×10^{-9}	7.44×10^{-8}
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.61×10^{-9}	3.04×10^{-9}	4.65×10^{-9}
Aroclor-1260	6.53×10^{-9}	2.06×10^{-9}	2.62×10^{-9}
Arsenic	1.13×10^{-8}	3.38×10^{-10}	7.26×10^{-8}
Barium	1.41×10^{-8}	3.30×10^{-8}	1.18×10^{-6}
Beryllium	6.24×10^{-10}	5.61×10^{-13}	8.11×10^{-9}
Boron	1.14×10^{-7}	2.13×10^{-7}	1.62×10^{-6}
Cadmium	2.44×10^{-9}	4.44×10^{-9}	5.21×10^{-8}
Carbazole	NA	NA	9.96×10^{-10}
Chromium	7.02×10^{-8}	1.91×10^{-8}	1.66×10^{-7}
Cobalt	1.95×10^{-7}	1.95×10^{-8}	1.27×10^{-7}
Copper	2.17×10^{-7}	3.25×10^{-8}	2.78×10^{-7}
Cyanide	1.37×10^{-14}	4.39×10^{-15}	3.11×10^{-9}
Endrin	1.84×10^{-11}	2.67×10^{-12}	2.00×10^{-11}
Lead	6.65×10^{-9}	5.54×10^{-9}	2.86×10^{-7}
Manganese	3.25×10^{-7}	2.84×10^{-7}	1.04×10^{-5}
Mercury	7.60×10^{-8}	1.37×10^{-10}	3.79×10^{-9}
Molybdenum	3.43×10^{-8}	8.58×10^{-9}	8.07×10^{-8}
Nickel	1.13×10^{-7}	1.89×10^{-8}	2.44×10^{-7}
Selenium	1.03×10^{-8}	2.74×10^{-9}	8.90×10^{-9}
Silver	2.07×10^{-8}	1.38×10^{-7}	8.80×10^{-8}
Tetrachlorodibenzo-p-dioxin	NA	NA	2.80×10^{-15}
Thallium	1.84×10^{-8}	9.19×10^{-10}	5.98×10^{-9}
Thorium	NA	NA	3.13×10^{-7}
Uranium	1.22×10^{-7}	3.66×10^{-7}	7.94×10^{-6}
Vanadium	5.51×10^{-8}	4.41×10^{-10}	2.87×10^{-7}
Zinc	9.03×10^{-6}	9.03×10^{-7}	9.81×10^{-7}
2-Methylnaphthalene	NA	NA	5.31×10^{-10}
4,4-DDE	5.29×10^{-10}	1.03×10^{-10}	1.42×10^{-10}

TABLE I.6-22
(Continued)

Radionuclides	Meat Concentration (pCi/kg)	Dairy Product Concentration (pCi/kg)	Vegetable Concentration (pCi/kg)
Cs-137	1.01×10^{-5}	3.55×10^{-6}	6.51×10^{-6}
Np-237	2.11×10^{-5}	2.31×10^{-6}	2.65×10^{-6}
Pa-231	1.66×10^{-5}	1.04×10^{-7}	2.70×10^{-6}
Pb-210	NA	NA	1.12×10^{-5}
Pu-238	1.58×10^{-10}	3.15×10^{-11}	4.10×10^{-6}
Pu-239	3.96×10^{-11}	7.92×10^{-12}	1.03×10^{-6}
Pu-240	1.44×10^{-10}	2.88×10^{-11}	3.75×10^{-6}
Ra-226	5.09×10^{-8}	1.41×10^{-7}	4.17×10^{-6}
Ra-228	8.90×10^{-8}	2.46×10^{-7}	7.29×10^{-6}
Rn-222	NA	NA	3.62×10^{-1}
Ru-106	NA	7.81×10^{-32}	4.38×10^{-17}
Sr-90	NA	1.78×10^{-27}	4.09×10^{-16}
Tc-99	NA	3.47×10^{-19}	7.50×10^{-8}
Th-228	1.39×10^{-9}	1.78×10^{-9}	4.75×10^{-6}
Th-230	1.62×10^{-8}	1.35×10^{-8}	3.51×10^{-5}
Th-232	5.88×10^{-9}	4.90×10^{-9}	1.28×10^{-5}
U-234	9.27×10^{-2}	3.34×10^{-1}	4.54×10^{1}
U-235	2.46×10^{-3}	8.86×10^{-3}	1.20×10^{0}
U-236	1.01×10^{-3}	3.64×10^{-3}	4.94×10^{-1}
U-238	5.54×10^{-2}	1.99×10^{-1}	2.71×10^{1}

NA = Not Available

000245

TABLE I.6-23

MODELED FARM PRODUCT COC CONCENTRATIONS: OFF-SITE RESIDENT FARM RECEPTORS, FUTURE LAND USE

Chemical	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/kg)	Vegetable Concentration (mg/kg)
Antimony	9.17×10^{-9}	9.86×10^{-10}	7.44×10^{-8}
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.61×10^{-9}	3.04×10^{-9}	4.65×10^{-9}
Aroclor-1260	6.53×10^{-1}	2.06×10^{-9}	2.62×10^{-9}
Arsenic	1.13×10^{-8}	3.38×10^{-10}	7.26×10^{-8}
Barium	1.41×10^{-8}	3.30×10^{-8}	1.18×10^{-6}
Beryllium	6.24×10^{-10}	5.61×10^{-13}	8.11×10^{-9}
Boron	1.14×10^{-7}	2.13×10^{-7}	1.62×10^{-6}
Cadmium	2.44×10^{-9}	4.44×10^{-9}	5.21×10^{-8}
Carbazole	NA	NA	9.96×10^{-10}
Chromium	7.02×10^{-8}	1.91×10^{-8}	1.66×10^{-7}
Cobalt	1.95×10^{-7}	1.95×10^{-8}	1.27×10^{-7}
Copper	2.17×10^{-7}	3.25×10^{-8}	2.78×10^{-7}
Cyanide	1.37×10^{-14}	4.39×10^{-15}	3.11×10^{-9}
Endrin	1.84×10^{-11}	2.67×10^{-12}	2.00×10^{-11}
Lead	6.65×10^{-9}	5.54×10^{-9}	2.86×10^{-7}
Manganese	3.25×10^{-7}	2.84×10^{-7}	1.04×10^{-5}
Mercury	7.60×10^{-8}	1.37×10^{-10}	3.79×10^{-9}
Molybdenum	3.43×10^{-8}	8.58×10^{-9}	8.07×10^{-8}
Nickel	1.13×10^{-7}	1.89×10^{-8}	2.44×10^{-7}
Selenium	1.03×10^{-8}	2.74×10^{-9}	8.90×10^{-9}
Silver	2.07×10^{-8}	1.38×10^{-7}	8.80×10^{-8}
Tetrachlorodibenzo-p-dioxin	NA	NA	2.80×10^{-15}
Thallium	1.84×10^{-8}	9.19×10^{-10}	5.98×10^{-9}
Thorium	NA	NA	3.13×10^{-7}
Uranium	1.22×10^{-7}	3.66×10^{-7}	7.94×10^{-6}
Vanadium	5.51×10^{-8}	4.41×10^{-10}	2.87×10^{-7}
Zinc	9.03×10^{-6}	9.03×10^{-7}	9.81×10^{-7}
2-Methylnaphthalene	NA	1.03×10^{-10}	5.31×10^{-10}
4,4-DDE	5.29×10^{-10}	9.86×10^{-10}	1.42×10^{-10}

TABLE I.6-23
(Continued)

Radionuclides	Meat Concentration (pCi/kg)	Dairy Product Concentration (pCi/kg)	Vegetable Concentration (pCi/kg)
Cs-137	1.01×10^{-5}	3.55×10^{-6}	6.51×10^{-6}
Np-237	2.21×10^{-4}	2.41×10^{-5}	2.65×10^{-6}
Pa-231	1.66×10^{-5}	1.04×10^{-7}	2.70×10^{-6}
Pb-210	NA	NA	1.12×10^{-5}
Pu-238	1.58×10^{-10}	3.15×10^{-11}	4.10×10^{-6}
Pu-239	3.96×10^{-11}	7.92×10^{-12}	1.03×10^{-6}
Pu-240	1.44×10^{-10}	2.88×10^{-11}	3.75×10^{-6}
Ra-226	5.09×10^{-8}	1.41×10^{-7}	4.17×10^{-6}
Ra-228	8.90×10^{-8}	2.46×10^{-7}	7.29×10^{-6}
Rn-222	NA	NA	3.62×10^{-1}
Ru-106	NA	7.81×10^{-32}	4.38×10^{-17}
Sr-90	NA	1.78×10^{-27}	4.09×10^{-16}
Tc-99	NA	1.04×10^{-18}	2.25×10^{-7}
Th-228	1.39×10^{-9}	1.78×10^{-9}	4.75×10^{-6}
Th-230	1.62×10^{-8}	1.35×10^{-8}	3.51×10^{-5}
Th-232	5.88×10^{-9}	4.90×10^{-9}	1.28×10^{-5}
U-234	2.62×10^{-1}	9.43×10^{-1}	1.28×10^{2}
U-235	6.96×10^{-3}	2.51×10^{-2}	3.41×10^{0}
U-236	2.87×10^{-3}	1.03×10^{-2}	1.40×10^{0}
U-238	1.57×10^{-1}	5.65×10^{-1}	7.68×10^{1}

NA = Not Available

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TABLE I.6-24

MODELED FARM PRODUCT COC CONCENTRATIONS: ON-SITE RESIDENT FARM RECEPTORS, FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

Chemical	Meat Concentration (mg/kg)	Dairy Product Concentration (mg/kg)	Vegetable Concentration (mg/kg)
Antimony	1.08×10^{-2}	1.08×10^{-3}	6.85×10^{-2}
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	7.54×10^{-3}	2.38×10^{-3}	2.39×10^{-3}
Aroclor-1260	9.63×10^{-3}	3.03×10^{-1}	1.38×10^{-3}
Arsenic	2.55×10^{-2}	7.64×10^{-4}	1.31×10^{-2}
Barium	1.17×10^{-1}	2.72×10^{-1}	6.24×10^{-1}
Beryllium	7.55×10^{-4}	6.80×10^{-7}	3.23×10^{-3}
Boron	1.80×10^{1}	3.37×10^{1}	9.59×10^{1}
Cadmium	5.36×10^{-2}	9.74×10^{-2}	2.23×10^{-1}
Carbazole	NA	NA	9.96×10^{-10}
Chromium	7.89×10^{-2}	2.15×10^{-2}	3.17×10^{-2}
Cobalt	3.63×10^{-1}	3.63×10^{-2}	3.63×10^{-2}
Copper	4.14×10^{0}	6.21×10^{-1}	2.16×10^{0}
Cyanide	2.52×10^{-7}	8.10×10^{-8}	3.11×10^{-9}
Endrin	3.10×10^{-6}	4.50×10^{-7}	1.33×10^{-6}
Lead	1.94×10^{-2}	1.62×10^{-2}	9.05×10^{-2}
Manganese	5.08×10^{0}	4.44×10^{0}	2.09×10^{1}
Mercury	2.43×10^{0}	4.38×10^{-3}	1.83×10^{-2}
Molybdenum	1.36×10^{-1}	3.41×10^{-2}	1.67×10^{0}
Nickel	4.75×10^{-1}	7.91×10^{-2}	5.81×10^{-1}
Selenium	1.66×10^{-2}	4.42×10^{-3}	6.75×10^{-3}
Silver	3.71×10^{-1}	2.47×10^{0}	2.58×10^{-1}
Tetrachlorodibenzo-p-dioxin	NA	NA	2.80×10^{-15}
Thallium	1.56×10^{-2}	7.81×10^{-4}	9.54×10^{-5}
Thorium	NA	NA	3.13×10^{-7}
Uranium	1.22×10^{-7}	3.66×10^{-7}	7.94×10^{-6}
Vanadium	5.04×10^{-2}	4.03×10^{-4}	3.33×10^{-2}
Zinc	4.84×10^{2}	4.84×10^{1}	2.47×10^{1}
2-Methylnaphthalene	NA	NA	5.31×10^{-10}
4,4-DDE	5.90×10^{-4}	1.15×10^{-4}	3.86×10^{-4}

TABLE I.6-24
(Continued)

Radionuclides	Meat Concentration (pCi/kg)	Dairy Product Concentration (pCi/kg)	Vegetable Concentration (pCi/kg)
Cs-137	5.26×10^{1}	1.84×10^{1}	7.49×10^{0}
Np-237	6.16×10^{-3}	5.88×10^{-4}	3.58×10^{-1}
Pa-231	1.66×10^{-5}	1.04×10^{-7}	2.70×10^{-6}
Pb-210	NA	NA	4.03×10^{0}
Pu-238	2.37×10^{-5}	4.74×10^{-6}	1.75×10^{-31}
Pu-239	3.27×10^{-6}	6.53×10^{-7}	2.42×10^{-4}
Pu-240	1.19×10^{-5}	2.38×10^{-6}	8.82×10^{-4}
Ra-226	9.63×10^{-2}	2.14×10^{-1}	2.50×10^{-1}
Ra-228	1.69×10^{-1}	3.75×10^{-1}	4.39×10^{-1}
Rn-222	NA	NA	3.62×10^{-1}
Ru-106	NA	1.79×10^{-25}	4.40×10^{-11}
Sr-90	1.25×10^{-1}	2.23×10^{-19}	3.36×10^{-9}
Tc-99	7.95×10^{0}	1.72×10^{-17}	1.01×10^{-6}
Th-228	1.21×10^{-3}	9.65×10^{-4}	1.42×10^{-2}
Th-230	3.29×10^{-4}	2.74×10^{-4}	2.19×10^{-3}
Th-232	6.93×10^{-3}	5.87×10^{-3}	2.17×10^{-2}
U-234	4.82×10^{0}	1.51×10^{1}	5.29×10^{2}
U-235	2.00×10^{-1}	6.15×10^{-1}	1.47×10^{1}
U-236	1.28×10^{0}	3.85×10^{0}	1.72×10^{1}
U-238	3.15×10^{0}	9.82×10^{0}	3.17×10^{2}

NA = Not Available

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I.7.0 TOXICITY ASSESSMENT

This toxicity assessment examines information concerning the potential effects of exposure to COCs. The COCs described in this section apply to the FEMP as a whole; they are the result of the Section I.4.0 screening process and are used in the Section I.6.0 fate and transport models. Those COCs that were screened out have been omitted from this discussion (see Section I.4.0 for a complete list).

For this CRARE, the goal was to quantitatively estimate the relationship between COC exposure and the severity or probability of human biological effect. Throughout this assessment, potential health effects caused by concurrent exposure to multiple COCs were assumed to be additive in nature. This assumption of additivity ignores possible synergisms or antagonisms among chemicals. However, data to assess interactions are lacking. In the absence of adequate information, EPA guidelines indicate that carcinogenic risks and noncancer hazard indices (HIs) should be treated as additive (EPA 1986b and 1989l).

This section contains a compilation of chronic noncarcinogenic and carcinogenic risk parameters followed by detailed toxicity profiles of the major COCs. The toxicity profiles emphasize chronic noncarcinogenic and carcinogenic health effects. Subchronic health effects are also addressed as necessary for the major COCs. The toxicity assessment for ecological effects will be provided in future operable unit CRAREs when such effects are evaluated.

I.7.1 NONCARCINOGENS

Reference doses (RfDs) and dose-response data for noncarcinogenic effects associated with exposure to the COCs are presented in Table I.7-1. Since the RfD is usually based on data from exposure studies using animal models, an uncertainty factor has been incorporated to provide a safety factor for the extrapolation from animals to humans. When available, RfDs for both the ingestion and inhalation pathways are presented. The sources for reference dose values and dose-response data were the IRIS database (EPA 1993b) and the HEAST compiled by EPA (1992c). IRIS was used as the primary source for toxicity information. HEAST was used only if IRIS values were unavailable (EPA 1989b).

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TABLE I.7-1
REFERENCE DOSES[a]

Chemical	Chronic Oral Reference Dose (mg/kg/day)	Chronic Inhalation Reference Dose (mg/kg/day)	Reference Concentration (mg/m^3)	Target Organ (Critical Effect)[b]		Uncertainty Factor	
				Oral	Inhalation	Oral	Inhalation
Inorganics							
Antimony	4×10^{-4}	ND	ND	Whole body (Increased Mortality); Blood (Altered Chemistries)	ND	1000	ND
Arsenic	3×10^{-4}	ND	ND	Skin (Keratosis; Hyperpigmentation)	ND	3	ND
Barium	7×10^{-2}	1.0×10^{-4}	5×10^{-4}	CVS (Increased Blood Pressure)	Fetus (Fetotoxicity)	3	1000
Beryllium (Soluble Salts)	5×10^{-3}	ND	ND	None (None Observed)	ND	100	ND
Boron	9×10^{-2}	5.7×10^{-3}	2×10^{-2}	Testis (Lesions)	Respiratory Tract (Irritation)	100	100
Cadmium (Food)	1×10^{-3}	ND	ND	Kidney (Proteinuria)	ND	10	ND
Cadmium (Water)	5×10^{-4}	ND	ND	Kidney (Proteinuria)	ND	10	ND
Chromium (VI)	5×10^{-3}	ND	ND	None (None Observed)	ND	500	300
Cobalt	6×10^{-2}	3×10^{-7}	1×10^{-6}	Heart (Cardiomyopathy)	Lung (Lesions)	ND	ND
Copper	ND	ND	ND	ND	ND	ND	ND
Cyanide	2×10^{-2}	ND	ND	Whole Body (Decreased Weight); Thyroid (Effects); Nerve (Myelin Degeneration)	ND	100	ND
Lead and Compounds (Inorganic)	ND	ND	ND	ND	ND	ND	ND
Manganese (Oral and Food)	1.4×10^{-1}	1.1×10^{-4}	4×10^{-4}	CNS (Effects)	CNS (Psychomotor Disturbances), Lung (Respiratory Effects)	1	300
Manganese (Water)	5×10^{-3}	ND	ND	CNS (Effects)	ND	1	ND
Mercury, Inorganic	3×10^{-4}	8.6×10^{-5}	3×10^{-4}	Kidney (Effects)	CNS (Neurotoxicity)	1000	30
Molybdenum	5×10^{-3}	ND	ND	Urine (Increased Uric Acid)	ND	30	ND

See footnotes at end of table.

TABLE I.7-1
(Continued)

Chemical	Chronic Oral Reference Dose (mg/kg/day)	Chronic Inhalation Reference Dose (mg/kg/day)	Reference Concentration (mg/m^3)	Target Organ (Critical Effect)[b]		Uncertainty Factor	
				Oral	Inhalation	Oral	Inhalation
Inorganics (cont.)							
Nickel	2×10^{-2}	ND	ND	Whole Body (Decreased Weight); Major Organs (Decreased Weight)	Cancer	300	ND
Selenium	5×10^{-3}	ND	ND	Whole Body (Selenosis)	ND	3	ND
Silver	5×10^{-3}	ND	ND	Skin (Argyria)	ND	3	ND
Thallium (Sulfate)	8×10^{-5}	ND	ND	None (None observed)	ND	3000	ND
Thorium	ND	ND	ND	ND	ND	ND	ND
Uranium	3×10^{-3}	ND	ND	Kidney (Nephritis)	ND	1000	ND
Vanadium	7×10^{-3}	ND	ND	ND	ND	100	ND
Zinc	3×10^{-1}	ND	ND	Blood (Decrease in Erythrocyte Superoxide Dismutase)	ND	3	ND
Semivolatiles							
Polychlorinated biphenyls[b]	ND	ND	ND	ND	ND	ND	ND
DDE	ND	ND	ND	ND	ND	ND	ND
Endrin[b]	3×10^{-4}	ND	ND	CNS (Convulsions), Liver (Lesions)	ND	100	ND

[a]The values in this table, except where noted in other footnotes, are from the OU2 RI report (DOE 1994a).
[b]IRIS (EPA 1994a), HEAST (1993c).

CNS = Central nervous system
CVS = Cardiovascular system
ND = No data available

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I.7.2 CHEMICAL CARCINOGENS

The incremental lifetime cancer risk (ILCR) due to exposure to a chemical was calculated as the product of the lifetime chronic daily intake (mg/kg/day) and the cancer slope factor of that chemical. The values used for carcinogenic slope factors (Table I.7-2) came entirely from EPA sources (IRIS and HEAST) and were defined by EPA's Carcinogen Assessment Group (CAG).

In developing the cancer slope factors, the EPA gave preference to human epidemiology studies; however, the slope factors for most chemicals were in fact derived from animal exposure studies. An inherent assumption in the EPA's approach is that there is no threshold for a carcinogenic effect. That is, smaller doses result in a smaller risk, but any dose, no matter how small, carries some risk. The dose-related number of tumors and the time of incidence of tumors were fitted using a linear multi-stage model. A slope factor describing the linear relationship of lifetime risk to dose was computed using the 95 percent UCL of this slope. This approach is inherently conservative because of the no-threshold assumption and the use of the 95 percent UCL.

Dermal Reference Doses and Cancer Slope Factors

For this CRARE, dermal RfD values and cancer slope factors were calculated from the corresponding oral values. To calculate a dermal RfD, the oral RfD was multiplied by the gastrointestinal absorption efficiency factor, expressed as a fraction. The resulting dermal RfD is based on absorbed dose. This is the appropriate value with which to compare dermal doses, because are they are expressed as absorbed rather than exposed doses. In a similar manner, and for the same reasons, to calculate a dermal cancer slope factor, the oral slope factor was divided by the gastrointestinal adsorption efficiency. This is because cancer slope factors are expressed as reciprocal doses. Dermal RfD values and cancer slope factors for the COCs in Operable Units 1 and 2 are presented in Table I.7-3.

The most important aspect in calculating a dermal RfD or cancer slope factor is the accuracy of the gastrointestinal absorption efficiency factor. For this reason, the toxicity profiles contain pharmacokinetics discussions in which the oral absorption data were evaluated. Where appropriate, the low (i.e., most conservative) end of the range of available gastrointestinal absorption data for humans was used to derive the dermal RfD or cancer slope factor. When the human data were insufficient, animal data were used. Data from high-dose experiments were not

TABLE I.7-2

CANCER SLOPE FACTORS FOR CHEMICALS[a]

Chemical	Oral Cancer Slope Factor [(mg/kg/day)-1]	Inhalation Cancer Slope Factor [(mg/kg/day)-1]	Unit Risk $(\mu g/m^3)^{-1}$	Tumor Site		Cancer Classification
				Oral	Inhalation	
Inorganics						
Antimony	ND	ND	ND	ND	ND	ND
Arsenic	1.8×10^{0}	1.5×10^{1}	4.3×10^{-3}	Skin, Lung	Respiratory System	A
Barium	ND	ND	ND	ND	ND	ND
Beryllium	4.3×10^{0}	8.4×10^{0}	2.4×10^{-3}	Total Tumors	Lung	B2
Boron	ND	ND	ND	ND	ND	ND
Cadmium	ND	6.1×10^{0}	1.8×10^{-3}	ND	Respiratory System	B1
Chromium (VI)	ND	4.1×10^{1}	1.2×10^{-2}	ND	Lung	A
Cobalt	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND	D
Cyanide	ND	ND	ND	ND	ND	D
Lead (Inorganic)	ND	ND	ND	ND	ND	B2
Manganese	ND	ND	ND	ND	ND	D
Mercury (Inorganic)	ND	ND	ND	ND	ND	D
Molybdenum	ND	ND	ND	ND	ND	ND
Nickel (Refinery Dust)	ND	8.4×10^{-1}	2.4×10^{-4}	ND	Respiratory System	A
Selenium (Selenium Sulfide)	ND	ND	ND	Liver, Lung	ND	B2
Silver	ND	ND	ND	ND	ND	D
Thallium	ND	ND	ND	ND	ND	D
Thorium	ND	ND	ND	ND	ND	ND
Uranium	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND
Zinc	ND	ND	ND	ND	ND	D

See footnotes at end of table

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TABLE I.7-2
(Continued)

Chemical	Oral Cancer Slope Factor [(mg/kg/day)-1]	Inhalation Cancer Slope Factor [(mg/kg/day)-1]	Unit Risk ($\mu g/m^3)^{-1}$	Tumor Site		Cancer Classification
				Oral	Inhalation	
Semivolatiles						
2-Methylnapthalene	ND	ND	ND	ND	ND	ND
Carbazole[b]	2.0×10^{-2}	ND	ND	Liver	ND	B2
TCDD, 2, 3, 7, 8	1.5×10^{5}	1.5×10^{5}	3.3×10^{-5} $(pg/m^3)^{-1}$	Respiratory System, Liver	ND	B2
Pesticides / PCBs						
4,4-DDE	3.4×10^{-1}	ND	ND	Liver	ND	B2
Endrin	ND	ND	ND	ND	ND	D
Polychlorinated Biphenyls	7.7×10^{0}	ND	ND	Liver	ND	B2

[a]Except where qualified by other footnotes, the values in this table are from the OU2 RI report (DOE 1994a).
[b]HEAST (EPA 1993c).

ND = No data available

TABLE I.7-3

DERMAL REFERENCE DOSES AND CANCER SLOPE FACTORS FOR COCs

Chemical		Gastrointestinal Absorption Fraction	Dermal Reference Dose (mg/kg-day)	Dermal Slope Factor $(mg/kg\text{-}day)^{-1}$
Inorganics				
Antimony		0.15	6.00×10^{-5}	ND
Arsenic		0.95	2.85×10^{-4}	1.90×10^{0}
Barium		0.91	6.37×10^{-2}	ND
Beryllium		0.01	5.00×10^{-5}	4.30×10^{2}
Boron		0.05	4.50×10^{-3}	ND
Cadmium	(Water)		2.50×10^{-5}	ND
	(Food)	0.05	5.00×10^{-5}	ND
Chromium (VI)		0.45	2.25×10^{-3}	ND
Cobalt		0.45	2.70×10^{-2}	ND
Copper		0.60	2.20×10^{-2}	ND
Cyanide		0.72	ND	ND
Lead		NA	ND	ND
Manganese	(Water)		1.50×10^{-4}	ND
	(Food)	0.03	4.20×10^{-3}	
Mercury		0.15	4.50×10^{-5}	ND
Molybdenum		0.38	1.90×10^{-3}	ND
Nickel		0.05	2.00×10^{-3}	ND
Selenium		0.80	4.00×10^{-3}	ND
Silver		0.05	ND	ND
Thallium		1.00	6.00×10^{-5}	ND
Thorium		NA	ND	ND
Uranium		0.05	1.50×10^{-4}	ND
Vanadium		0.05	3.50×10^{-4}	ND
Zinc		0.25	7.50×10^{-2}	ND
Semivolatiles				
Carbazole		0.90	ND	2.22×10^{-2}
2-Methylnaphthalene		1.00	ND	ND
Pesticide/PCBs				
Polychlorinated biphenyls		0.75	5.30×10^{-5}	1.03×10^{1}
4,4-DDE		0.90	ND	3.78×10^{-1}
Endrin		0.90	2.70×10^{-4}	ND
Dioxins/furans		0.50	ND	3.00×10^{5}

SOURCE: OU2 RI report (DOE 1994a)

ND = No data available
NA = Not applicable

used if more suitable data were available and it appeared the gastrointestinal absorption process could have been saturated. When adequate quantitative data were not located, a default gastrointestinal absorption factor was used.

As noted by EPA (1989a), the gastrointestinal absorption of many metals from the gastrointestinal tract is limited, and 0.05 is a reasonable default for metals and inorganic substances. The EPA (1989a) did not recommend a separate default value for organic chemicals. A compilation of data for 19 organic chemicals presented gastrointestinal absorption efficiencies of at least 0.9, indicating that organic chemicals generally are readily absorbed. The arithmetic average of the efficiencies for the 19 organic chemicals, 0.91368 (equivalent to 0.9 when rounded to one significant figure), appears to be a reasonable default gastrointestinal absorption efficiency factor for organic chemicals. The default of 0.9 was used for organic chemicals for which quantitative data were not adequate.

I.7.3 RADIOCARCINOGENS

The principal adverse biological effects associated with ionizing radiation from radioactive substances in the environment are mutagenicity, teratogenicity, and carcinogenicity:

- Mutagenicity is the ability to induce genetic mutations in the nuclei of either somatic or reproductive cells.
- Teratogenicity is the ability to induce or increase the incidence of congenital malformations, which are permanent structural or functional deviations produced during embryonic growth and development.
- Carcinogenicity is the ability to produce neoplastic changes which result in tumors.

The guidance for the EPA Superfund risk assessment clearly states that carcinogenicity is considered to be the limiting deleterious effect at the radiation dose levels expected at the remediated FEMP. The carcinogenic effects may then be used as the sole basis for assessing the radiation-related human health risks of a site contaminated with radionuclides (EPA 1989l).

Each radionuclide produces a unique radiation spectrum and can affect different organs in the human body. The EPA has calculated the annual radiation dose equivalent from each radionuclide to each organ in each year of life, per unit intake or external exposure, over a

lifetime. The average excess number of all types of radiation-induced fatal cancers that occur in a year can then be estimated for the corresponding dose equivalents received during that year and relevant preceding years. The excess number of radiation-induced fatal cancers is derived from epidemiological data, extrapolation from high radiation doses to low doses, and mathematical models for projecting risk over a lifetime. Because the EPA is concerned with assessing cancer incidence, each radionuclide slope factor has been calculated by dividing the excess fatal cancer risk for that radionuclide by the mortality-to-incidence risk ratio (EPA 1989l) for the types of cancer induced by that radionuclide. This mortality-to-incidence risk ratio is not incorporated into the cancer potency factors derived by EPA for chemical carcinogens; therefore, the basis for cancer risk estimates for radionuclides and chemical carcinogens is not the same.

The relationship between cancer incidence and exposure to radioactive materials is quantified by using mathematical extrapolation models, which estimate the largest possible linear slope (within the 95 percent UCL) at low extrapolated doses consistent with the data. This "radiocarcinogenicity slope factor" is characterized as the "maximum likelihood estimate of the age-averaged lifetime total excess cancer risk per unit intake or exposure" (EPA 1991f). For this reason, the true risk to humans, although not identifiable, is not likely to be the upperbound estimate. It may in fact be lower.

The EPA Office of Radiation Programs (ORP) has calculated cancer slope factors for radionuclides of potential concern at Superfund sites. These values are listed in the HEAST (not IRIS) and are subject to revision. The slope factors are presented in Table I.7-4.

I.7.4 RADIATION EXPOSURE PATHWAYS

EPA and DOE use different methodologies to evaluate human health risk from radiation. The purpose of this section is to distinguish these two methods and define radiation considerations for the analysis used in this CRARE. The pathways of exposure and the mathematical models used to evaluate the potential health risks associated with radionuclides in the environment are similar to those used for evaluating COCs.

TABLE I.7-4

CANCER SLOPE FACTORS FOR RADIONUCLIDES

Radionuclide	ICRP Lung Class[a]	Inhalation Risk/(pCi)	Ingestion Risk/(pCi)	External Exposure (Risk/year per pCi/g soil)
Cs-137 + Progeny	D	1.9×10^{-11}	2.8×10^{-11}	2.0×10^{-6}
Np-237 + Progeny	W	2.9×10^{-8}	2.2×10^{-10}	4.3×10^{-7}
Pa-231	Y	3.6×10^{-8}	9.2×10^{-11}	2.6×10^{-8}
Pb-210 + Progeny	D	4.0×10^{-9}	6.6×10^{-10}	1.6×10^{-10}
Pu-238	Y	3.9×10^{-8}	2.2×10^{-10}	2.8×10^{-11}
Pu-239	Y	3.8×10^{-8}	2.3×10^{-10}	1.7×10^{-11}
Pu-240	Y	3.8×10^{-8}	2.3×10^{-10}	2.7×10^{-11}
Ra-226 + Progeny	W	3.0×10^{-9}	1.2×10^{-10}	6.0×10^{-6}
Ra-228 + Progeny	W	6.9×10^{-10}	1.0×10^{-10}	2.9×10^{-6}
Rn-222 + Progeny	Gas	7.7×10^{-12}	1.7×10^{-12}	5.9×10^{-6}
Ru-106	Y	4.4×10^{-10}	9.5×10^{-12}	0.0×10^{0}
Sr-90 + Progeny	D	6.2×10^{-11}	3.6×10^{-11}	0.0×10^{0}
Tc-99	W	8.3×10^{-12}	1.3×10^{-12}	6.0×10^{-13}
Th-228 + Progeny	Y	7.8×10^{-8}	5.5×10^{-11}	5.6×10^{-6}
Th-230	Y	2.9×10^{-8}	1.3×10^{-11}	5.4×10^{-11}
Th-232	Y	2.8×10^{-8}	1.2×10^{-11}	2.6×10^{-11}
U-234	Y	2.6×10^{-8}	1.6×10^{-11}	3.0×10^{-11}
U-235 + Progeny	Y	2.5×10^{-8}	1.6×10^{-11}	2.4×10^{-7}
U-236	Y	2.5×10^{-8}	1.5×10^{-11}	2.4×10^{-11}
U-238 + Progeny	Y	5.2×10^{-8}	2.8×10^{-11}	3.6×10^{-8}

[a] Classification recommended by the ICRP for half-time of clearance from the lung: Y = years, W = weeks, D = days.

Source: HEAST (EPA 1993c)

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Radionuclides found at contaminated sites behave in the environment like their nonradioactive isotopes. Consequently, the types of data needed for a radiation risk assessment are similar to those required for a chemical risk assessment. The primary differences lie in the procedures used to characterize the radionuclide contaminants. Exposure pathways for radionuclides include both internal and external pathways. Intakes by inhalation, ingestion, and dermal absorption are the important internal pathways.

The quantification of the amount of energy deposited in living tissue due to internal and external exposure to ionizing radiation is termed "radiation dosimetry." The amount of energy deposited in living tissue is of concern because the potential adverse effects of radiation are proportional to energy deposition. Therefore, the term "dose," used regarding radiation exposure, is defined as the energy imparted to a unit mass of tissue, whereas chemical dose means the mass of chemical absorbed into an organism.

Despite the fundamental difference between the way exposures are expressed for radionuclides and chemicals, the approach to exposure assessment is the same. An exposure assessment for radionuclides involves three steps: 1) characterization of the exposure setting, 2) identification of the exposure pathways, and 3) quantification of exposure. The primary differences in conducting exposure assessments for radionuclides as compared to chemicals are: 1) consideration of external exposures, 2) conversion of radiation exposures to dose equivalents, and 3) modification of fate and transport models for radiation exposure.

Toxicity assessment for radionuclides generally follows a two-step process. The first step, hazard identification, is used to determine whether exposure can increase the incidence of an adverse health effect. The second step, dose response assessment, is used to quantify the toxicity information and characterize the relationship between the dose of the contaminant administered or received and the incidence of adverse health effects in the exposed population.

Exposure to a radioactive substance is assumed to be hazardous. An extensive body of literature exists on radiation carcinogenesis in man and animals. Ionizing radiation can be considered pancarcinogenic (i.e., it acts as a complete carcinogen in that it serves as both initiator and promotor and can induce cancers in almost any tissue or organ).

With regards to the mutagenic effects of radiation, very little quantitative data are available. particularly low-dose exposures. The bulk of evidence supporting the mutagenic character of ionizing radiation comes from extensive studies using animal models, which have demonstrated all forms of radiation mutagenesis. Mutation rates calculated from these studies have been extrapolated to humans and form the basis for estimating the genetic impact of ionizing radiation on humans.

Radiation is a well-known teratogenic agent. The developing fetus is much more sensitive to radiation than is the mother. The age of the fetus at the time of exposure is the most important factor in determining the extent and type of damage from radiation. The malformations produced in the embryo depend on which cells, tissues, or organs in the fetus are most actively differentiating at the time of radiation exposure. Embryos are relatively resistant to radiation-induced teratogenic effects during the later stages of their development and are most sensitive from just after implantation until approximately 8 weeks into term. The greatest risk of brain damage for the human fetus occurs from 8 to 15 weeks into term.

The dose-response assessment of radionuclides is straight-forward compared to that of chemicals. The type of effects and the likelihood of possible adverse health effects occurring from radiation exposure depends on the radiation dose. The probability of adverse health effects increases with the dose of radiation, but the severity of the effects is independent of dose.

Estimates of human health effects are based primarily on single, acute, high doses of radiation. The current model used to describe these effects as a function of dose is called the linear quadratic model. This model assumes that there is no threshold for the induction of cancer or genetic effects. It is assumed that any radiation dose could give rise to a cancer or genetic effect. This is a conservative assumption and a conservative model. There is very little data on the effects of radiation at low doses or on the effects of chronic, long-term exposure in humans.

Human Health Effects

Two major international groups have been responsible for collecting and evaluating data on the human health effects of ionizing radiation, the Committee on the Biological Effects of Ionizing Radiations (BEIR) of the National Research Council, and the United Nations Scientific

Committee on the Effects of Atomic Radiation (UNSCEAR). These groups have issued a series of reports presenting the data and recommendations on risk values. The EPA is responsible for developing guidelines for radiation risk assessment in the United States and has relied on the published evaluations of these groups, along with those of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP). The following discussion contains a brief overview of effects of ionizing radiation on human health, and the relative risks associated with these effects.

Carcinogenic Effects. Radiation effects are usually separated into low and high linear energy transfer (LET) effects for risk evaluation. LET refers to the rate at which energy is lost as the particle or gamma ray travels through matter. Low LET radiation include x-rays and gamma rays. High LET radiation includes alpha particles and some beta particles. High LET radiation is more cytotoxic and oncogenic than low LET radiation. The EPA (1989) has estimated the following cancer risks factors for estimating risks associated with radiation exposure:

Risk	Exposure Period	Radiation	Risk Factor $(rem)^{-1}$
Fatal Cancers	Lifetime	Low LET	3.9×10^{-4}
		High LET	3.1×10^{-3}
All Cancers	Lifetime	Low LET	6.2×10^{-4}
		High LET	5.0×10^{-3}
Fatal Cancers	In utero	Low LET	6.0×10^{-4}

Cancer slope factors for individual radionuclides are presented as Table I.7-4.

Genetic Effects. Genetic effects have been studied extensively using animal models and in the Japanese atomic-bomb survivors. A comparison of the survivor data has consistently led to estimates of genetic effects that imply lower risks in humans than in animals (NRC 1990). Taking into account the confidence intervals associated with the various data, the difference between humans and animals remains, indicating that humans are less sensitive to radiation induction of mutations in germ cells, and that risks derived from animal data will be conservative if applied to humans. Because of this, BEIR V and UNSCEAR have based their evaluation of genetic risk on the lower 95 percent confidence limit for Japanese atomic-bomb survivor data, which is also

consistent with the range of doubling doses observed in mice. A doubling dose is the dose required to double the incidence of genetic defects in a population.

The doubling dose for humans is currently estimated to be 100 rem (NRC 1990). Genetic effects expected per rem per 30-year generation, based on this doubling dose, fall into the range of less than 1 to about 100 per million liveborn offspring for multi-generations. The natural incidence for genetic anomalies ranges from 400 to 30,000 per million liveborn offspring (NRC 1990).

The EPA has recommended (1989) a genetic risk of 2600 effects per rad per 30-year generation for low LET radiation where 1 rad equals approximately 1 rem, and 6900 per rad per 30-year generation for high LET radiation (alpha and beta radiation) where 1 rad equals approximately 0.05 to 1 rem (depending on energy, LET, etc). These risks are based on the older BEIR III report. This is slightly more restrictive than the current BEIR V estimates.

Teratogenic Effects. Teratogenic effects are somatic effects resulting from exposure in utero to ionizing radiation. These effects, which are not passed on to other generations, can include severe mental retardation, microcephaly, and structural or limb abnormalities. Extrapolating the results of animal studies to humans has proved difficult because of the significant differences in fetal development rates. The EPA (1989) uses an estimate of 4000 effects per rad of exposure during weeks 8 to 15 of gestation for low LET radiation (primarily gamma radiation).

I.7.5 TOXICITY PROFILES: RADIONUCLIDES

This section presents toxicity information for radionuclide compounds. It was assumed that all radionuclides are present in the soils as oxides or carbonates. This represents a conservative assumption because radionuclides clear slowly from environmental media.

I.7.5.1 Cesium-137

Pharmacokinetics

The gastrointestinal uptake of cesium is rapid, and its absorption coefficient is around 85 percent in mammals. The half-life of cesium is thought to average 80 days. The EPA (1993c) has derived a gastrointestinal absorption factor for cesium of 1.0, equivalent to 100 percent.

The physiological properties of cesium resemble those of potassium, although quantitative differences arise in transport by cell membranes; cesium can displace potassium from muscle and red cells. Potassium enters the cells via sodium-potassim dependent ATPase. Cesium ions are effective in activating this enzyme and compete with potassium for carrier sites (Davie and Coleman 1988).

Noncarcinogenic Toxicity

Cesium salts can be regarded as being virtually nontoxic. However, in acute animal studies, the hydroxide was approximately 10 times more toxic than the chloride, bromide, or iodide. Acute toxicity, which was observed only at very high cesium concentrations (10 to 20 mmol Cs/kg) in mice, is characterized by dysautonomic upset with parasympathetic predominance and a multiphasic exitation/depression action on the central nervous system. The organs most affected appear to be the liver, intestine, heart, and kidneys.

In beagles injected with massive doses of Cs-137, early deaths occurred as a result of bone marrow destruction (Davie and Coleman 1988).

Carcinogenic Toxicity

In beagles injected with massive doses of Cs-137, neurofibrosarcoma cancers occurred in the survivors (Davie and Coleman 1988).

The EPA has derived cancer slope factors for cesium and its progeny, and they are presented in Table I.7-4.

I.7.5.2 Lead-210

Noncarcinogenic Toxicity

Data regarding the noncarcinogenic toxicity of Pb-210 were not located.

Carcinogenicity

The EPA has derived cancer slope factors for Pb-210, and they are presented in Table I.7-4.

I.7.5.3 Neptunium-237

Neptunium isotopes have not presented unusual problems in occupational radiation protection, nor have they, until recently, caused special environmental concern. Attention has recently been directed to the potential environmental exposure to the long-lived Np-237, which is estimated to be the principal surviving component of high-level nuclear waste after ten or twenty thousand years. Np-237 has a half-life of 2.14×10^6 years and is primarily produced in nuclear reactors via the (n,2n) and (n,8) nuclear reactions with uranium. Its presence in the high-level nuclear waste, and its presumed environmental mobility, has made it an isotope of special environmental concern. It has been estimated that Np-237 may be the most hazardous remaining constituent of high-level nuclear waste during the interval from 10,000 to 30,000 years following disposal.

Pharmacokinetics

The fraction of ingested neptunium absorbed from the gastrointestinal tract into blood (F_1) is currently assumed to be 0.01. This value was based on experimental data involving a large group of rats fed with doses of neptunium exceeding 1 mg/kg. When the dietary dose was lower than 1 mg/kg, the fraction F_1 was 0.001 or less. Data on distribution and retention of neptunium in rats indicate that its metabolic behavior is similar to that of plutonium. However, there are some indications that neptunium may distribute more like calcium than like plutonium in the skeleton. Forty-five percent of the neptunium leaving the transfer compartment will be translocated to mineral bone. Another 45 percent will be transported to the liver, and 0.035 percent to the testes or 0.011 percent to the ovaries. The remaining neptunium leaving the transfer compartment is assumed to go directly to excreta. The biological half-life of neptunium is about 100 years in

mineral bone, about 40 years in the liver, and it is assumed that neptunium is permanently retained in the gonads. These retention and translocation data were based on the ICRP common model for systemic distribution and retention of all transuranic elements. The model itself was largely based on plutonium data.

Noncarcinogenic Toxicity

All animal toxicity studies with neptunium have employed Np-237. Because of its low specified activity (0.76 mCi/g), the chemical toxicity effects of Np-237 are often observed to the exclusion of radiation effects. Soviet data in this area were studied by Moskalev et al (NCRP 1988). The concern was not with the chemical effects. Although such effects might be a controlling factor in an acute exposure to Np-237, they would not be an important factor at the usual levels concerning radiation protection, and certainly not at the very low levels of potential environmental exposure. Therefore, health effects are assessed only with respect to carcinogenicity.

Carcinogenicity

The effects of neptunium exposure have not been studied in man. For radiation protection purposes, it has been assumed that radiation doses resulting from neptunium deposition in organs and tissues will result in biomedical effects similar to those observed following the exposure of humans to other sources of ionizing radiation. The very limited data on neptunium effects in animals provide no direct useful estimates of risk to humans. Although these data play no direct role in establishing neptunium standards, they can nevertheless help to validate these standards through comparisons with other animal studies employing other radionuclides.

The long-term radiation effects of Np-237 have been studied only in rats. Genetic effects have not been studied. Bone cancer has been the predominant long-term effect of low-level injections of Np-237. Both lung and bone cancer incidences are elevated following inhalation exposure. There is no indication that neptunium at low exposure levels constitutes a unique health risk unpredictable from its general radiological characteristics.

The 1987 NCRP recommendations for annual limits on Np-237 intake are as follows:

• Oral ingestion	0.6 μCi	Based on nonstochastic limits
	2.0 μCi	Based on stochastic limits
• Inhalation	0.005 μCi	Based on nonstochastic limits
	0.010 μCi	Based on stochastic limits

The nonstochastic limit or dose equivalent applies to bone surface.

The EPA has derived cancer slope factors for neptunium, and they are presented in Table I.7-4.

I.7.5.4 Plutonium

There are no reports on the chemical toxicity of plutonium; however, the fibrosis observed in the lungs of exposed animals and humans could be due to chemical interactions. The radiologic toxicity of plutonium involves bone necrosis, bone and lung cancer, and detrimental effects on the reproductive system. Also, toxic effects are observed in offspring of pregnant animals exposed to plutonium. No ingestion data specific to plutonium are available.

Among the plutonium isotopes, the short-lived Pu-241 is especially toxic because of the high energy associated with its alpha particle emission. The toxicity of plutonium compounds is based primarily on the very high radiotoxicity of the plutonium atom and secondarily upon whatever atoms or combinations of atoms they might contain (Sax 1989). When inhaled, plutonium is retained in the lungs with an effective half-life that varies from hundreds of days for plutonium oxides to tens of days for more soluble forms. A significant portion of the plutonium oxide that leaves the lungs is translocated to the tracheobronchial lymph nodes. Plutonium solubilized within the lungs is translocated to the liver and skeleton where it is very tenaciously retained (Klaassen 1986).

In a classic long-term toxicity study performed by Bair et al., the effects of inhaled plutonium oxide were studied in beagle dogs for up to 10 years following inhalation exposure. At the highest levels of deposited activity, the dogs died within several hundred days with radiation pneumonitis and pulmonary fibrosis; at later times death was related to severe pulmonary fibrosis, and beyond 1000 days, although pulmonary fibrosis was still prominent, death was due to primary pulmonary neoplasia. The most common neoplasm was bronchioloalveolar carcinoma (Klaassen 1986). Hahn et al. (1983), using data reported by Bair and Thomas (1976), calculated the risk

factor for Pu-239 alpha irradiation of the lungs to be 600 lung tumors per million rad to lung, or, assuming an RBE of 20, 30 lung tumors per millirem to lung.

Human data for plutonium exposure are available. Among workers contaminated, the case histories have been documented of 26 men who worked with plutonium during World War II. The initial body burden of these workers was between 540 and 229,500 pCi (reported as between 20 and 8500 Becquerel), and 11 of them received doses exceeding the maximum allowed by the International Commission for Radiological Protection. After a medical follow up of 37 years, 2 members of this group died of myocardial infarction and accidental trauma, respectively, compared to the 6.6 deaths expected on the basis of the adjusted rates for white males. Their 1982 exam provided no evidence that 37 years of exposure to internally deposited plutonium had adverse effects on their health (Seiler 1988).

Less toxicity data are available on trans-plutonium radionuclides such as americium and curium; however, the data that are available indicate a qualitative similarity to the toxicity of plutonium. McClellan, et al. (1972) noted that inhaled americium and curium, even as oxides, appeared more soluble than inhaled plutonium and rapidly translocated to the liver and skeleton. (Klaassen 1986)

Carcinogenicity

The EPA classifies all radionuclides as weight-of-evidence Group A substances (human carcinogens), based on their characteristic of emitting ionizing radiation and on the extensive epidemiologic data associating exposure with radiogenic cancers in humans (EPA 1992d). The carcinogenicity of Pu-238 (the predominate plutonium isotope at the FEMP) from internal exposure is due to alpha particles. The EPA (1992d) has reported cancer potency slope factors for the plutonium isotopes, and these are presented in Table I.7-4.

I.7.5.5 Protactinium-231

Pharmacokinetics

Experiments with laboratory animals treated orally with different forms of protactinium yielded absorption efficiencies ranging from 0.01 to 1 percent (Burkart and Kopp 1988). The EPA (1992d) reported a gastrointestinal absorption factor of 0.001 equivalent to 0.1 percent. Quantitative inhalation data for protactinium have not been located, but one case of human

inhalation yielded a lung clearance half-life 1000 days (Burkart and Kopp 1988). An ICRP lung class designation of "Y" indicates that clearing inhaled protactinium would be expected to take years.

Absorbed protactinium is distributed principally to the skeleton, and to a lesser extent to the liver and kidneys. Protactinium in the blood is excreted directly (Burkart and Kopp 1988), but the route and rate of excretion are not specified.

Noncarcinogenic Toxicity

Data regarding the noncarcinogenic effects of protactinium have not been located.

Carcinogenicity

The EPA classifies all radionuclides as weight-of-evidence Group A substances (human carcinogens), based on their characteristic of emitting ionizing radiation and on the extensive epidemiologic data associating exposure with radiogenic cancers in humans (EPA 1992d). The carcinogenicity of protactinium-231 is due to its emission of alpha particles (Burkart and Kopp 1988). The EPA (1992d) presents cancer potency slope factors for protactinium-231 of 9.2×10^{-11} per pCi for ingestion, 3.6×10^{-8} per pCi for inhalation, and 2.6×10^{-8} per pCi yr/g for external exposure.

I.7.5.6 Radium and Radon

Noncarcinogenic Toxicity

No chemical toxic effects of exposure to radium has been documented, and the EPA has not developed an RfD for radium; therefore, the health hazard for radium is associated with potential radiocarcinogenic effects.

Carcinogenicity

Four isotopes of radium occur naturally, Ra-223 (actinium series), Ra-224 and Ra-228 (thorium series), and Ra-226 (uranium series); radium is ubiquitous in the earth's crust and common in groundwater, mineral deposits, soil, food products, and common building materials. Ra-226 has the longest half-life (1600 years) of the radium isotopes and decays by alpha particle emission. Ra-223 and Ra-224 are also alpha-particle emitters, and Ra-228 is a beta-particle emitter. The

primary uses of radium are for manufacturing luminous dials and instrument faces and for internal radiation therapy. Thus, the bulk of human data on the effects of radium intake are available from studies of radium-dial painters and medical patients who have been administered therapeutic doses of radium.

Radium introduced into the body generates decay products, including gaseous isotopes of radon. Rn-222 generated in the body persists long enough that it easily diffuses into the bloodstream and accumulates in the sinuses, significantly reducing the alpha dose to the radium accumulating tissues but increasing the dose in the sinuses. Ultimately the bone tissues are the principal site of radium accumulation because of the similar chemistry of radium and calcium (NAS 1988). In the bone tissues, radium is initially deposited in endosteal bone surface tissue. There is then a redistribution to the bone volume, where the radium resides with a long retention time.

Dose Response Data - Human and Animal

The following discussion of the health effects of radium exposure is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988). The epidemiological studies of humans were initially stimulated by the appearance of cancer and other adverse health effects associated with occupational exposures to Ra-224, Ra-226, and Ra-228 (by the radium-dial painters). The dial painters had the potential to ingest significant quantities of radium that were known to be harmful. The second most significant study group comprised ankylosing spondylitis patients, who were administered doses of radium solutions for therapeutic reasons. Most of the other studies focused on bone cancer, cancer of the paranasal sinuses, and cancer of the mastoid air cells, because the association of these effects with radium exposure was well known.

Although epidemiological investigations have documented the association between radium exposure and carcinogenic effects, there has been considerable debate over the dose-response relationship involved. Bone cancer incidence has been evaluated as a function of a variety of parameters that represent a measure of radium exposure, such as absorbed dose to the skeleton, pure radium equivalents, and cumulative rad-years (Evans 1966). The results indicated a nonlinear relationship fits the data. A separate analysis of the same bone cancer induction data confirmed the finding of a nonlinear fit (Mays and Lloyd 1972). The conclusion from both of these analyses is that a linear nonthreshold relationship is likely to significantly over-predict

cancer incidence at low doses. Later reassessments presented a linear-quadratic-exponential dose-response relationship (Rowland et al. 1971, 1978a, 1978b, 1983) and a dependence of incidence on the square of radium intake normalized to body weight (Marshall and Groer 1977).

Two extensive studies of ankylosing spondylitis patients treated in Germany with solutions of Ra-224 are most noteworthy. In the first, a 900-patient cohort treated with a Ra-224 colloid during the period from 1946 to 1951 with a follow-up period for more than 30 years, revealed bone cancer incidence associated with the high absorbed doses from the therapeutic treatments (Spiess 1969; Spiess and Mays 1970, 1973). In the second study, a cohort of about 1400 patients treated with small doses of Ra-224 for ankylosing spondylitis showed a similar association between dose and cancer induction (Spiess 1969; Spiess and Mays 1970, 1973). The analyses were consistent with a variety of dose-response relationships; however, none can be disproved because of the scatter in the data.

Cancers of the paranasal sinuses and the mastoid air cells have been associated with exposure to Ra-226 and Ra-228 since the 1930s (Martland 1939). These effects were initially seen in the radium-dial painters, who received high absorbed doses from the quantities of radium they ingested. Excess incidence is evident when compared to the natural incidence, which is very low. After exposure to radium, these types of cancers were expressed later than bone cancers (Evans et al. 1969; Finkel et al. 1969; Rowland et al. 1971; Rundo et al. 1986).

As discussed above, Rn-222 generated in the body persists long enough that it easily diffuses into the bloodstream and accumulates in the sinuses, significantly increasing the dose in the sinuses. Studies of cancers of the sinuses and mastoid cells conducted in beagle dogs injected with a variety of alpha-emitting radionuclides revealed excess incidence of these cancers (Schlenker 1980). Not all of the tumors were induced by alpha emitters that produce a gaseous decay product; therefore, a gaseous decay product was not essential to induction. Nevertheless, the risk of these cancers from Ra-226 and its decay products (including Rn-222) is considered significantly greater than from other alpha-emitting radionuclides.

The incidence of leukemia and other blood diseases among the radium-dial painters has been linked to radium ingestion. Martland (1931) demonstrated development of anemias and

leukopenia (low leukocyte count) in the dial painters. Evans' study (1966) included leukemia and anemia as possible effects of radium accumulation in the body. Finkel et al. (1969) discovered cases of leukemia and aplastic anemia in studies of the radium-dial painters exposed from 1918 to 1933. Among a cohort of 634 female dial painters first employed before 1930, three deaths were attributed to leukemia (Polednak 1978). This final study exceeded expectations because the natural incidence of leukemia is very low. An epidemiological study of 1285 women employed as dial painters before 1930, and 1185 employed between 1930 and 1949 (when radium contamination and exposures were much lower) revealed standard mortality ratios of 73 and 221, respectively (Stebbings et al. 1984). However, the most comprehensive and definitive study of U.S. dial painters include all workers employed before 1970 (Spiers et al. 1983). Ten cases of leukemia were found among the worker cohort of 2940 persons. The expected number of natural cases for this group would be 9.2. The study concluded that the incidence in the cohort does not differ significantly from natural incidence (Spiers et al. 1983). In summary, the accumulation of very high levels of radium is associated with severe anemias and leukemia (NAS 1988). However, at lower levels of accumulation, such as those experienced by the majority of U.S. radium-dial painters, especially in later years, the accumulated radium does not appear to significantly increase the risk of leukemia (NAS 1988).

The BEIR IV Committee presented a cancer risk factor of 200 x 10^{-6} per rad for bone sarcomas from protracted exposure to radium in its report on radon and other alpha emitters (NAS 1988).

I.7.5.7 Radon and Progeny

Toxicity

There are no known toxic effects of exposure to radon gas or its short-lived progeny. However, short-lived radon progeny decays to relatively long-lived lead. Because lead is a chemical toxicant, significant accumulations of radon pose a potential source of lead for exposure pathways to receptors.

Carcinogenicity

Exposure to air contaminated with radon gas and associated airborne progeny has been linked to increased risk of lung cancer. The risk is attributed to inhalation of the short-lived progeny of radon that are attached to particulates, which lodge in the lung passages and produce a radiation

dose that causes lung cancer. Radon progeny that do not lodge in the lung passages are exhaled, and do not deliver a radiation dose. Lung cancer results when the bronchial epithelium of the lung passages is exposed to alpha particles emitted from decaying radon progeny (i.e., Po-214 and Po-218) lodged in the lung passages.

Three isotopes of radon are of potential concern, one associated with each of the three natural decay series. Rn-222, Rn-220, and Rn-219 are members of the uranium, thorium, and actinium decay series, respectively. Rn-222 is the isotope of primary concern because its half-life 3.82 days and mobility as an inert gas facilitate its outdoor and indoor migration, thus potentially exposing receptors to elevated concentrations of Rn-222 and its short-lived progeny. Rn-220 (half-life, 55.6 seconds) and Rn-219 (3.96 seconds) are generally of less concern because their very short half-lives often result in decay before these can migrate and accumulate in elevated quantities where receptors may be exposed. For example, all three isotopes of radon may be of concern in the air in buildings that contain the appropriate parent radionuclides (in the form of surface contamination or drummed material, for example). At the FEMP, however, Rn-220 and Rn-219 are not expected to be released from a source such as the K-65 silos because their short half-lives cause them to decay before migrating out of the waste matrix or out of the containment provided by the silos.

Dose Response Data - Human and Animal

The following discussion regarding the health effects of exposure to radon and radon progeny is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988). The radiological effect of concern from exposure is lung cancer.

The lung cancer hazard associated with working in underground mines was first recognized by Harting and Hesse in 1879 as a result of autopsies of European miners (Harting and Hesse 1879). The most important human populations studied with regard to radon progeny exposure were the underground miners exposed to widely differing concentrations of airborne Rn-222 progeny in mines (NCRP 1984). The lung cancer mortality risk estimates for radon progeny exposure published by the BEIR IV Committee (NAS 1988) were based on an epidemiological study of these underground miner populations. The assessment of the risk from exposure to radon

progeny by the BEIR IV Committee represents the most recent comprehensive examination of estimated health risks associated with exposure.

The BEIR IV Committee relied heavily on data from four principal studies of miners: Ontario uranium miners, Saskatchewan uranium miners, Swedish metal miners, and Colorado Plateau uranium miners. Underground miners exposed to radon progeny (in the mines) have an increased risk of lung cancer, as demonstrated in these epidemiological study populations. Animal models experimentally exposed to airborne radon progeny also developed lung cancers. To supplement the information available from the human epidemiological studies, animal model studies have provided information on the dose-response relationship and the effects of variations in the exposure rate, physical characteristics of the lungs, and air quality. Thus, both human epidemiological data and animal experimental data indicate that exposure to radon progeny induces lung cancer. The data also describe the relationship between exposure and health effect as a function of influencing factors.

In its study of the human epidemiological data, the BEIR IV Committee has reevaluated the primary data (i.e., exposure histories and mortality) for the four principal epidemiological study groups of underground miners exposed to radon progeny. From this reevaluation, the committee has estimated the risk of developing fatal lung cancer. The risk from lifetime exposure to radon progeny is 350 x 10^{-6} excess fatal lung cancers per cumulative working level month (WLM) as exposure. The WLM is defined as the cumulative exposure to an airborne concentration of short-lived radon progeny (equal to one working level) for a period of one working month. It must be noted that this estimate, quantified as fatal lung cancer risk, was based primarily on epidemiological studies of humans and is expressed per unit cumulative exposure to progeny (WLM^{-1}). The EPA slope factors addressing cancer incidence were based on calculated radiation doses to organs and tissues and are expressed per unit radioactivity intake (pCi^{-1}). Thus, the EPA and BEIR IV risk estimates are not directly comparable. The EPA cancer slope factors were used to assess risk attributable to radon and radon progeny exposure. It is also noted that EPA has adopted a nominal risk estimate of 360 x 10^{-6} per WLM for use in NESHAPS (EPA 1989l). This estimate was based primarily on EPA's consideration of the BEIR IV assessment; however, EPA did average radon risk estimates derived from BEIR IV and ICRP models to calculate the estimate of 360 x 10^{-6} per WLM.

Although the carcinogenicity of radon progeny is established and the hazards of exposure during mining are well recognized, the hazards of exposure in other environments have not yet been adequately quantified (NAS 1988). A few exploratory epidemiological studies of lung cancer risk associated with radon progeny exposure in homes have been conducted; however, the results are inconclusive and inadequate for the purpose of risk estimation (NAS 1988).

The model developed by the BEIR IV Committee may be used to estimate risks under other environmental conditions to which persons may be routinely exposed; however, it must be recognized that the committee's model was based on epidemiological evaluations of occupational exposure conditions in underground mines. Therefore, assumptions must be made regarding the similarity of exposed populations, levels of exposure, and factors such as cigarette smoking, when using the model for nonoccupational conditions such as the indoor home environment.

Using the BEIR IV risk factor (NAS 1988) of 350×10^{-6} WLM^{-1} for lung cancer mortality from inhalation of Rn-222 and progeny, and by assuming 51.5 working months per year (8760 hours per year divided by 170 hours worked per month), 100 pCi Rn/liter air, short-lived Rn-222 progeny present in 50 percent equilibrium, and an inhalation rate of 20 m^3/day for 365 days/year, one can derive a lung cancer mortality risk factor of 1.2×10^{-11} per pCi. The EPA cancer slope factor from HEAST for inhalation of Rn-222 plus progeny is 7.7×10^{-12} per pCi (EPA 1992d). It must be noted that the BEIR IV risk estimate pertains to lung cancer mortality, while the EPA cancer slope factors all pertain to cancer induction rather than cancer fatality.

I.7.5.8 Ruthenium-106

Pharmacokinetics

The biochemistry and metabolism of ruthenium and its salts have not been investigated in detail. Ruthenium chelates are readily absorbed and rapidly excreted. A transient retention of ruthenium occurs in the kidneys, muscle, liver, bone, and probably also in the lungs during experiments using radioruthenium chloride.

Once absorbed into the bone, ruthenium is retained for a long time (Léonard 1988).

The EPA (1993c) has derived a gastrointestinal absorption factor for ruthenium of 0.05, equivalent to 5 percent.

Noncarcinogenic Toxicity

Most ruthenium salts are considered to be slightly toxic, but fumes of ruthenium tetroxide and of ruthenium heated in air are highly injurious to the eyes and the lung and can produce nasal ulcerations.

Acute LD_{50} values after intraperitoneal administration of $RuCl_3$ range from 108 mg/kg (mouse) to 360 mg/kg (rat); after oral treatment, they range from 210 mg/kg (guinea pig) to 460 mg/kg (mouse). $RuCl_3OH$ is less toxic: acute LD_{50} values are 660 mg/kg (mouse) and 1250 mg/kg (rat) after oral administration, and 225 mg/kg (mouse) after intraperitoneal administration.

Ruthenium red is a known antagonist of Ca^{+2} and inhibits Ca^{+2} transport and binding in mitochondria membranes and muscle tissues. This salt also inhibits Ca^{+2}-ATPase activity.

Ruthenium red is also an antagonist of the depressive action of noradrenaline and 5-hydroxytryptamine on cortical neurons, and by action on neurotransmitters it can produce paralysis and convulsions in laboratory animals (Léonard 1988).

Carcinogenicity

The EPA has derived cancer slope factors for Ru-106, which are presented in Table I.7-4.

I.7.5.9 Strontium

Pharmacokinetics

Wenning and Kirsch (1988) reported that the gastrointestinal absorption of soluble strontium compounds ranges from 5 to 25 percent of the ingested dose and the EPA (1992d) has derived a gastrointestinal absorption efficiency factor of 0.3. Insoluble strontium compounds are absorbed to about 5 percent. Data regarding inhalation or dermal absorption has not been located.

Strontium is an alkaline earth metal similar in chemical behavior to calcium (Wenning and Kirsch 1988). About 99 percent of the body burden is in the skeleton. Excretion is principally in the urine.

Noncarcinogenic Toxicity

Stable strontium has induced rachitic changes in the bones, particularly of the young (EPA 1992d). Presumably, Sr-90 would also induce rachitic changes in bone. The concern at the FEMP, however, is with the radiological effects (carcinogenicity) of Sr-90, rather than the noncarcinogenic toxicity.

Carcinogenicity

The EPA (1992d) has assigned stable strontium to cancer weight-of-evidence Group D, indicating it is not classifiable as to humans carcinogenicity. Quantitative cancer risk estimates were not derived for Group D substances. The EPA classifies all radionuclides as Group A substances (human carcinogens), based on their characteristic of emitting ionizing radiation and on the extensive epidemiologic data associating exposure with radiogenic cancers in humans (EPA 1992d). The EPA (1992d) has derived cancer potency slope factors for Sr-90, and its radioactive decay product of 3.6×10^{-11} per pCi for ingestion and 6.2×10^{-11} per pCi for inhalation exposure. There is no slope factor for external exposure to Sr-90, which does not emit penetrating radiation (gamma- or x-rays).

I.7.5.10 Technetium

Noncarcinogenic Toxicity

No isotopes of technetium are stable (Clarke and Podbielski 1988). Lethality due to radiation toxicity usually occurs before the nonradiologic effects of technetium become manifest; hence, little is known of the metabolic effects of the element.

Carcinogenicity

The EPA classifies all radionuclides as weight-of-evidence Group A substances (human carcinogens), based on their characteristic of emitting ionizing radiation and on the extensive epidemiologic data associating exposure with radiogenic cancers in humans (EPA 1992d). The internal carcinogenicity of Tc-99 is due to its emission of beta particles (Clarke and Podbielski

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1988). The EPA (1992d) has derived cancer potency slope factors for Tc-99 of 1.3 x 10^{-12} per pCi for ingestion, 8.3 x 10^{-12} per pCi for inhalation, and 6.0 x 10^{-13} per pCi yr/g for external exposure.

I.7.5.11 Thorium

Noncarcinogenic Toxicity

No toxic effects of exposure to thorium have been documented, and the EPA has not developed an RfD for thorium; therefore, the health hazard for thorium is associated with its potential radiocarcinogenic effects.

Carcinogenicity

Natural thorium is present in the earth's crust as a primordial element. Th-232 isotope accounts for approximately 100 percent of the mass abundance of thorium; however, the other isotopes of thorium exist as members of the three natural decay series. The half-life of Th-232 is very long (approximately 10 billion years); thus the specific activity is relatively low and the rate of decay is slow. Th-232 decays by alpha particle emission, as do most of the progeny in the thorium natural decay series.

Thorium has historically been used as a medical imaging agent, because it is a heavy atom that provides contrast in radiographic imaging. In this role thorium has been used commercially as Thorotrast, a 25-percent colloidal solution of thorium dioxide. The following discussion of the health effects from thorium exposure is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988).

Thorotrast has been used extensively in the United States, Europe, and Japan as an intravascular contrast agent for cerebral and limb angiography. Thorotrast has also been injected into the spleen for hepatolienography and into nasal and paranasal sinuses. These uses of Thorotrast result in deposition of the thorium (and subsequent decay products) in tissues and organs of the body, most frequently in the reticuloendothelial tissues in bone (NAS 1988). Once deposited in these tissues, alpha particle emissions from the decay of Th-232 and its progeny irradiate the tissues for long periods of time at low-dose rates.

Dose-Response Data - Human

The data on human health effects of thorium exposure are based primarily on epidemiological studies of Thorotrast patients. The five long-term studies include German, Portuguese, Japanese, Danish, and American patients. In the German study (van Kaick et al. 1978a and b, 1983, 1984, 1986), 5159 Thorotrast patients and 5151 controls were followed since 1933 and 1935, respectively. The Thorotrast patients underwent intravascular injections of Thorotrast to enhance the imaging of cerebral and limb angiography. The results of the follow-up analysis indicated an excess of malignant cancers, most notably liver cancers and leukemias, among the patients relative to the controls.

The Portuguese study (Abbatt 1973; da Motta et al. 1979; Horta et al. 1978) involved about 2500 Thorotrast patients and 2000 controls with a follow-up period of about 30 years. The patients were exposed to Thorotrast from 1929 to 1955, with roughly 60 percent receiving Thorotrast doses for cerebral angiography. The results of the study show a significant excess of malignant cancer deaths among the patients compared to the control group. Particularly notable were the excess patient liver malignancies compared to the controls.

The Japanese study (Kato et al. 1979, 1983; Mori et al. 1979a, 1979b, 1983, 1986) included 282 Thorotrast patients who were administered Thorotrast for angiography and hepatolienography during World War II. The follow-up period spanned 38 to 46 years, and results revealed that patient mortality from malignant liver cancers, other malignant cancers, blood diseases, and cirrhosis of the liver was significantly higher than in the control group.

The Danish study (Faber 1973, 1977, 1978, 1979, 1983, 1986) involved 1319 Thorotrast patients injected with Thorotrast from 1935 to 1946. The epidemiological analysis revealed excess gastrointestinal malignancies, liver malignancies, malignancies of the lung, and leukemia deaths in patients compared to control individuals. The excess of liver malignancies and leukemias was most notable in the study.

The American study (Falk et al. 1979) is a preliminary epidemiological assessment of Thorotrast patients exposed from 1964 to 1974. All patients had received Thorotrast for either hepatolienography or cerebral angiography. A liver cancer incidence was evident in the

investigation and is reportedly continuing to increase. Further follow-up of these individuals is needed.

All five of these human epidemiological studies indicated an excess of malignant cancers among the Thorotrast patients compared to the controls. The excess malignancies were predominantly of the liver and blood (leukemia) types.

Estimation of Excess Risk from Thorotrast Administration

The human epidemiological evidence from the studies of Thorotrast patients represents the primary source of data from which estimates of risk have been derived (NAS 1988). These data can be used to derive estimates of risk for liver cancer and leukemia; however, such estimates strictly apply only to conditions of intravascular Thorotrast injection. The BEIR IV committee derived a risk estimate of up to 300 x 10^{-6} per rad of alpha particle radiation to the liver, and emphasized that these estimates are for Thorotrast, not thorium. The emphasis is because the dosimetry of other isotopes of thorium differs from that of Th-232 in the Thorotrast colloid form. BEIR IV also derived a risk estimate of up to 60 x 10^{-6} per rad of alpha radiation to bone marrow for leukemia, and a value of up to 120 x 10^{-6} per rad of alpha radiation to the skeleton without marrow for bone cancer (NAS 1988).

Dose Response Data - Animal

Experimental studies of animals administered modified Thorotrast solutions provide insight into the possible influence of Thorotrast on carcinogenicity in humans from a "foreign body effect" (i.e., from the colloid solution), or a toxicological effect of the thorium in addition to a radiation dose effect. Studies of mice administered Thorotrast solutions fortified with Th-230 to increase the specific activity of alpha emission delivering radiation dose to tissues, conventional Thorotrast, and zirconium dioxide solution (Zirconotrast) have provided evidence of increased carcinogenicity of Thorotrast relative to Zirconotrast (Bensted 1967). Rabbits injected with Th-230 enriched Thorotrast revealed a shortened latency period associated with the higher specific activity solution (Faber 1973). In mice, rabbits, rats, and dogs, the metabolic distribution of Thorotrast and other colloid solutions (including zirconium and hafnium dioxide colloids) has indicated that 1) the organ distribution of the Thorotrast and associated progeny in these animals is comparable to that

in humans (Riedel et al. 1979, 1983) and 2) the other colloids fail to reveal significantly different effects attributable to their distributions compared to the Thorotrast (Riedel et al. 1979, 1983).

A study of dose response and possible foreign body effect in rats (Wesch et al. 1973, 1983) was conducted by administering different Th-230 enrichments of Thorotrast (causing variations in dose rate) and by administering different volumes of Thorotrast (dilutions maintaining constant dose rate). The results demonstrated that the frequency of cancers follows a linear dependence with dose rate. However, varying the volume of Thorotrast administered did not correlate with frequency of induction. Although cancer risk did not increase with the volume of Thorotrast at a constant dose rate, the latent period was shortened (Wesch et al. 1973; 1983).

In additional studies of rats injected with Zirconotrast enriched with Th-228, the number of induced cancers increased, and the induced cancers were similar to those induced in humans by Thorotrast (Wesch 1986). The frequency of cancer induction was found to be dose-rate dependent, and the Zirconotrast without Th-228 did not induce excess cancers (Wesch 1986).

In summary, the animal experimental evidence indicates that Thorotrast induces cancers as a result of the radiation dose delivered by the solution. The physical presence of particles in the colloid solution and the chemical effect of the thorium are not likely to influence the induction of cancer (NAS 1988). The EPA derived slope factors are presented in Table I.7-4.

I.7.5.12 Uranium

Pharmacokinetics

In general, uranium compounds are not easily absorbed across the human gastrointestinal tract. Soluble uranium compounds demonstrate the best absorption. In a study in which patients drank a solution of uranyl nitrate hexahydrate, a water soluble compound, only 0.5 to 5 percent of the dose was absorbed (Hursh et al. 1969). Recent uranium metabolic models estimated absorption from the gastrointestinal tract to the blood to be 0.6 percent (Wrenn et al. 1987). Although human data concerning absorption by dermal exposure are sparse, water-insoluble uranium compounds were not absorbed in significant quantities across the skin (Yuile 1973) and are not believed to pose a significant risk to humans by this exposure route.

Once absorbed into the bloodstream, uranium compounds are metabolically converted to uranyl ions. The uranyl ion acts as a ligand in the systemic circulation, binding to the plasma proteins and bicarbonate. Although this uranyl-bicarbonate complex is stable at the pH of the plasma, the pH of urine favors dissociation of the complex. This leaves the uranyl ion free to bind to the tissues in the proximal tubule wall of the nephrons of the kidneys, resulting in cellular necrosis (Leggett 1989).

As well as being the only soft tissue that stores uranium in any appreciable quantity, the kidneys are the main organs of excretion (Hursh and Spoor 1973). Approximately 70 percent of an intake of uranium has been estimated to be excreted by the kidneys within 24 hours of intake (Berlin and Rudell 1979). Uranium that is not excreted is stored in the kidneys and bones. Binding to the bone is thought to be caused by the affinity of uranium for the phosphate groups in the bone structure.

Toxicity

Dose-Response Data - Human

Exposure to uranium, a chemical toxicant, leads to nephritis in the kidneys. Data on human exposure to uranium compounds were collected from 1940 to 1960 in acute studies on terminal and volunteer patients. Single injections of 70 to 100 μg/kg of uranium nitrate to terminally ill patients resulted in proteinuria and increased levels of catalase in the urine (Berlin and Rudell 1979; Luessenhop et al. 1958). In another study, patients were given uranyl nitrate injections ranging from 6.3 to 71 μg/kg. One of the early signs of renal damage, the appearance of the enzyme catalase in the urine, occurred in patients receiving 55 to 71 μg/kg (Hursh and Spoor, 1973; Leggett, 1989).

Dose-Response Data - Animal Models

Animal models have demonstrated a of variation of responses in acute intravenous toxicity studies. Rabbits and guinea pigs appear to be the most sensitive. The acute intravenous toxicity of soluble uranium compounds such as uranyl nitrate has been shown to be very high; the approximate dose at which 50 percent of the test organisms do not survive (LD_{50}) for rabbits is 0.1 mg/kg, for guinea pigs 0.3 mg/kg, for rats 1 mg/kg, and for mice 10 to 20 mg/kg (Stokinger 1982).

In chronic animal studies sublethal threshold doses of uranium have been demonstrated (Leggett 1989). Although the exact mechanism of tolerance is not known, it is believed that regenerated kidney tissue is associated with tolerance. When uranium exposure ceases, the regenerated epithelium transforms into normal renal tubular tissue (Yuile 1973).

An extensive chronic feeding study was performed on rabbits, rats, and dogs for periods of 30 days, 1 year, and 2 years (Maynard and Hodge 1949). These animals received uranium doses of 2.8, 14, and 71 mg/kg/day in the diet. Rabbits were maintained for 30 days, dogs for 1 year, and rats for 1 to 2 years. For all species, water soluble compounds were more toxic than insoluble compounds. The lowest observed adverse effect levels (LOAELs) were established for all compounds and each species (Maynard and Hodge 1949). In all cases, the LOAEL could be established within the first 30 days (EPA 1991f). Of the three species, rabbits appeared to be the most sensitive, with renal damage exhibited at all administered dose levels. The renal damage was judged to be only moderate at the lower doses, but moderately severe at the highest dose. Based on this study, the EPA has established the lowest uranium dose of 2.8 mg/kg/day as the LOAEL (EPA 1991f).

Basis for Reference Dose

The EPA (1991f) has established an RfD for uranium of 3 μg/kg/day. In lieu of a no observed adverse effect level (NOAEL), the RfD was based on the LOAEL of 2.8 mg/kg/day (Maynard and Hodge 1949) and an uncertainty factor of 1000. The uncertainty factor accounts for intraspecies and interspecies variability in toxicological response and for the use of the LOAEL rather than an NOAEL. No factor was included for the short duration of the exposure (30 days), because it has been shown that chronic nephrotoxic effects can be adequately characterized with experiments of acute/subacute duration (EPA 1991f).

Carcinogenicity

Uranium can induce cancer as a result of intake into the body through inhalation or ingestion pathways. The induction of cancer results when organs and tissues of the body are exposed to alpha particles emitted from decaying uranium atoms. Alpha particles are energetic emissions that cause molecular ionizations in a very dense pattern along a short path through matter. The effect of an alpha particle is highly localized due to the short path length traveled (low penetrability)

and the ability of the particle to produce many ionizations. The ionization events cause biological damage believed to be responsible for inducing cells to become cancerous. Although other energetic emissions from radioactive decay of atoms (such as beta particles and gamma rays) also cause molecular ionizations, these radiations do not produce the density of ionizations that alpha particles produce. The dense pattern of ionizations caused by alpha particles and the low penetrability of alpha particles are the factors that determine uranium is an internal exposure hazard. Alpha particles are not an external exposure hazard because they do not penetrate sensitive tissues from outside the body. The outer layers of the skin stop the alpha particles before they can penetrate and damage sensitive tissues of inner layers.

The type of uranium (i.e., natural, enriched, or depleted) under consideration is important because different types of uranium have different specific activities (the amount of radioactivity per unit mass). The value of the specific activity of the uranium reflects the number of alpha particles emitted per unit mass. This has a direct impact on the magnitude of the radiological dose delivered internally after the uranium enters the body. Naturally occurring uranium and uranium processed from natural uranium is a mixture of U-234, U-235, and U-238. The difference between natural, enriched, and depleted uranium is defined by the percent U-235 mass enrichment. The higher the U-235 enrichment, the higher the specific activity of the mixture.

Dose-Response Data - Human

The following discussion of data concerning human health effects of uranium exposure is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988). Convincing epidemiological evidence of uranium-induced radiocarcinogenic effects in humans is difficult to obtain. Available epidemiological evidence has come from studies of workers involved in uranium mining and milling operations. It has been noted for some time that uranium workers are at risk of increased cancer mortality; however, inhalation of airborne radon progeny rather than uranium particulates is considered the predominant source of radiation damage to the respiratory tract in uranium miners. Simultaneous exposures to radon progeny and other elements present in uranium ore are considered confounding factors in those studies of uranium miners intended specifically to examine the radiological effects of exposure to uranium.

Risk estimation for exposure to uranium is based heavily on the carcinogenic effects of other alpha-emitting radionuclides and on animal experiments involving exposure to uranium. Available human epidemiological studies are discussed below.

Epidemiological surveys of uranium workers began in the United States in 1950 (Miller et al. 1956), and reports of increased cancer risk among uranium millers in Europe began appearing in 1959 (Rockstroh 1959). In contrast, other studies have reported little evidence of a health hazard to workers in the uranium processing industry (Ely 1959). The BEIR IV committee (NAS 1988) cautioned that the validity of epidemiological studies on uranium effects must be considered in the context of the power or ability of the studies to detect an effect if one existed. This is important with regard to all of the available epidemiological studies on uranium effects.

An early U.S. Public Health Service study of uranium miners and millers in the Colorado Plateau reported no increase in mortality in the cohort of uranium millers studied (Wagoner et al. 1964). A more detailed study with longer follow-up of the same cohort (Archer et al. 1973) revealed that the number of deaths available for analysis was almost equal to the expected number of deaths determined among controls. Interpretation of the results is complicated because, 1) exposure data were not presented, 2) the excess cases included three diagnostic categories, 3) precautions were not taken (or not stated) to exclude individuals with underground mining exposure through previous employment, 4) and the analysis was not performed in relation to the length of exposure. Because of its weak epidemiological power, the study did not provide strong evidence that uranium has a specific effect.

Several studies of uranium workers exposed to enriched uranium have been performed. A study of workers at the enrichment facility in Oak Ridge between 1943 and 1947 indicated that the mortality of the study cohort was not increased for lung cancer, bone cancer, or nephrotoxic disorders (Polednak and Frome 1986). This study is weakened by data based on exposures of short duration (typically 1 to 2 years), which does not provide conclusive evidence concerning health effects from long-term (chronic) exposure. A subsequent study of a cohort from the same population examined the lung cancer risk from inhaling uranium dust (Cookfair et al. 1983). The results indicated an increased risk among the group of workers hired at, or over age 45, and the increased magnitude of risk was greater for higher exposures.

The findings of a retrospective study of uranium mill workers from the Colorado Plateau conducted to examine the health risks of uranium exposure in the absence of uranium mining (Waxweiler et al. 1983) were not statistically significant and are mitigated by the small number of deaths for workers employed for at least five years. The results did not reveal an increase in lung cancer deaths nor conclusively demonstrate an increased nephrotoxic effect.

Past epidemiological studies have failed to conclusively demonstrate health effects from chronic exposure to uranium dust involved in uranium mining and milling operations. However, this does not necessarily mean that the epidemiological data conclusively demonstrate the absence of effect. This is because the power of the studies was limited, weakened by short worker exposure durations, inadequate estimates of uranium exposures, and insufficient worker follow-up time to adequately evaluate long-term effects.

In conclusion, chronic exposure to uranium should be controlled on the basis of nephrotoxicity more than by radiocarcinogenicity from alpha particle emissions (NAS 1988). Quantification of the risk from chronic exposure to uranium alpha particles cannot be determined from published epidemiological studies because of confounding factors and the limited power of the studies to detect increased rates of cancer incidence or mortality (NAS 1988). Therefore, the BEIR IV Committee's a risk estimate for uranium was based on the carcinogenic effects of other alpha emitting radionuclides and animal experiments involving exposure to uranium. The most probable radiogenic effect is an increase in bone sarcomas. The likelihood of sarcomas from exposure to naturally occurring uranium is considered low and demonstrable only if a linear dose-response relationship is assumed (Mays et al. 1985). If the dose-response relationship is quadratic, then virtually no effect would be expected from naturally occurring uranium. Assuming a linear dose-response relationship and a constant nonoccupational uranium intake of 1 pCi/day, then the risk of bone sarcoma induction over a lifetime is estimated to be 1.5×10^{-6} or 1.5 bone sarcomas per million persons (Mays et al. 1985). This is compared to a natural incidence of 750 bone sarcomas in the absence of excess exposure.

Assuming a constant nonoccupational uranium intake rate of 1 pCi/day, an exposure frequency of 365 days/year, and a lifetime of 70 years, then a lifetime uranium intake of nearly 26,000 pCi is calculated. Using the risk factor from Mays (Mays et al. 1985) and dividing by the calculated

lifetime intake, one can derive a risk factor of 5.9 x 10^{-11} per pCi. A comparison of this risk factor with the cancer slope factors from HEAST for ingestion of U-234, U-235, and U-238 indicates that the ratios of the HEAST values to the former value are 2.4, 2.2, and 2.2, respectively.

Dose-Response Data - Animal Models

The following discussion of experimental data concerning adverse health effects of uranium exposure in animal models is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988). The effect of bone cancer induction is addressed first, followed by the effect of lung cancer induction.

The discussion of human epidemiological evidence presented above identifies the bone surfaces as the most probable target tissue for exposure to uranium, and bone sarcoma as the carcinogenic effect of concern. Radiocarcinogenic effects, including bone sarcoma and head carcinoma, have also been observed in animals and humans from exposure to isotopes of radium, and studies involving exposure of mice to high specific activity U-232 and U-233 have also revealed an increase in bone sarcomas. Soviet researchers have demonstrated that highly enriched uranium, which has a high specific activity, induces bone sarcomas in rats. These results indicate that the intake of high specific activity, alpha-particle-emitting radionuclides increases the risk of these cancers in animals. It would be reasonable to expect high specific activity uranium to induce bone sarcomas in humans; however, the likelihood that low specific activity, naturally occurring uranium induces bone sarcomas is low.

As stated in the discussion of human epidemiological evidence presented above an estimate of the excess risk of bone sarcoma in humans from chronic ingestion of uranium has been developed (Mays et al. 1985). This risk estimate was based on a linear dose-response relationship for Ra-226. Therefore, it was assumed that the response to alpha particles from uranium exposure is similar to the response to alpha particles from Ra-226. This assumption depends in part on the metabolic behavior of uranium relative to radium. There is evidence indicating that uranium seeks bone tissue in a manner similar but not identical to that of radium. U-233 administered to beagle dogs has been shown to initially deposit nonuniformly on bone surfaces; however, redistribution occurred (within approximately one year) to produce a distribution through the

bone volume that was similar to the distribution of radium (Stevens et al. 1980). Distribution of uranium throughout the bone volume in dogs has also been reported by Rowland and Farnham (1969) and Bruenger (personal communication with BEIR IV Committee, 1986 not available in bibliography).

Another concern is the induction of malignant tumors in the lungs from exposure to uranium by inhalation. As previously discussed, uranium emits alpha particles, which can deposit a highly localized radiation dose to sensitive tissues in the passages of the respiratory tract if particulate uranium is deposited in those passageways. The effects of inhaling of insoluble forms of uranium have been studied in rats, dogs, and monkeys for both short and prolonged exposure scenarios (Leach et al. 1970, 1973). The affected sites were the tissues of the lungs and the pulmonary lymph nodes. Chronic inhalation of uranium in these studies produced fibrosis of lung tissue and induction of malignant lung tumors. Data from those studies involving dogs have been reanalyzed (Durbin and Wrenn 1975), leading to the conclusion that neoplastic changes (tumor induction) began in the epithelial cells of the lungs in 21 percent of the dogs after a cumulative lung dose of 160 rads.

Another study exposed rats to U-232 and U-233 (as uranyl nitrate) by inhalation, revealing an increase in malignant lung tumors and bone sarcomas (Ballou et al. 1980). However, the significance of the bone sarcomas (osteosarcomas) is questionable because the rats exposed to control aerosols also developed these tumors. The osteosarcomas are not statistically significant because of their appearance in the control rats. The results of this study of high specific activity U-232 and U-233 uranyl nitrate could lead to the reasonable expectation that such exposure could induce malignant lung tumors in humans. However, the findings of this work do not provide the data needed to convincingly extrapolate a risk coefficient for human exposure.

I.7.6 TOXICITY PROFILES: CHEMICALS

I.7.6.1 4,4-DDE

In humans, 4,4-DDE is a major metabolic product of the metabolism of the organochlorine insecticide DDT. Four percent of technical DDT is composed of DDE (EPA 1993d). As a class, these insecticides are neuropoisons.

Noncarcinogenic Toxicity

DDT was used extensively during World War II to control lice and other insects by direct application to humans. There is no evidence that harm to these people resulted from this direct application. There seems to be no documented, unequivocal report of fatal human poisoning from DDT in spite of its past widespread use and availability. DDT is poorly absorbed after dermal exposure, especially when applied in the powder form. This poor absorption from the skin probably accounts for the rather good safety record of DDT in spite of its wide and sometimes careless use by applicators and formulators.

The signs and symptoms of poisoning in humans and animals resulting from high doses of DDT include paresthesia of the tongue, lips, and face; apprehension; hypersusceptibility to stimuli; irritability; dizziness; disturbed equilibrium; tremor; and tonic and clonic convulsions. Motor unrest and fine tremors associated with voluntary movements progress to coarse tremors without interruption in moderate to severe poisoning. It has been estimated that a dose of 10 mg/kg will cause signs of poisoning in humans.

Although the functional injury produced by high doses of DDT is referable to effects in the central nervous system, little pathologic change occurs there. Primary pathologic changes that result from exposure to high but nonfatal doses, or from subacute or chronic feeding, are observed in the liver. With large doses, centrolobular necrosis of the liver has been reported. Smaller doses result in liver enlargement, which in rodents is somewhat characteristic in that the cells and mitochondria themselves are enlarged. Histologic changes in the livers of male rats fed diets containing 5 to 15 ppm or more for 6 months include hypertrophy, inclusion bodies, and cytoplasmic granulation of a type in which the granules orient themselves around the periphery of the cell. DDT and related compounds induce mixed-function oxidase enzymes of the liver in

several species, including humans, and increases the incidence of liver tumors when fed in the diet of rodents.

DDT and one of its major metabolic products, DDE, have high fat-to-water partition coefficients and therefore tend to accumulate in adipose tissue. The adipose tissue concentrations of DDT in heavily exposed workmen have achieved amazingly high concentrations (in the hundreds of parts per million) without clinical evidence of injury. Following cessation of exposure, DDT is slowly eliminated from the body. Elimination has been estimated at a rate of approximately 1 percent of stored DDT excreted per day.

During the years of its most extensive use in the late 1950s and early 1960s, the average storage of DDT in human fat was about 5 ppm. Total storage of DDT derived from material was about 15 ppm; this consisted primarily of DDT and its lipophilic metabolite, DDE. With the declining use of DDT, there appears to have been a reduction in these levels so that the average adipose tissue level for humans in the late 1960s was 1 to 2 ppm of DDT and about 9 ppm of total DDT-derived materials. Corresponding in time with these observations, analyses of whole meals indicated that the average amount of DDT that an adult in the United States obtained from food decreased from approximately 0.2 mg in 1958 to only about 0.04 mg per day in 1970 (Murphy 1986).

The EPA has not derived chronic oral and inhalation reference doses for DDE.

Carcinogenicity

Human epidemiological data are not available for DDE.

The EPA has classified DDE as a cancer weight-of-evidence Group B2 substance (probable human carcinogen) based on liver tumors in mice and hamsters and thyroid tumors in female rats administered DDE in feed. The EPA has derived an oral cancer slope factor of 3.4×10^{-1} mg/kg/day (EPA 1993a).

I.7.6.2 2-Methylnaphthalene

Noncarcinogenic Toxicity

Data located regarding the noncancer toxicity of 2-methylnaphthalene are limited to an oral lowest dose associated with lethality (LD_{Lo}) in rats of 5000 mg/kg (Sax 1984). Neither oral nor inhalation RfD or RfC values were located.

Carcinogenicity

Data regarding the carcinogenicity of 2-methylnaphthalene were not located.

I.7.6.3 Antimony

Noncarcinogenic Toxicity

Chronic oral exposure studies in animal models include two briefly reported lifetime drinking water studies with potassium antimony tartrate in rats and mice that reported reduced longevity in both species and reduced mean heart weight and altered blood chemistry in the rats (EPA 1992d). A verified chronic oral RfD of 0.0004 mg/kg/day was based on the rat study and an uncertainty factor of 1000.

Chronic effects from occupational exposure include irritation of the respiratory tract, pneumoconiosis, pustular eruptions of the skin called "antimony spots," allergic contact dermatitis, and cardiac effects, including abnormalities of the ECG and myocardial changes (Elinder and Friberg 1986). Cardiac effects were also observed in rats and rabbits exposed by inhalation for six weeks, and in animals (dogs and possibly other species) treated by intravenous injection. Inhalation RfC values are not available from the EPA. The heart, respiratory tract, and skin are the principal target organs for antimony.

Carcinogenicity

Data were not located regarding the human carcinogenicity of antimony. Antimony fed to rats did not produce excess tumors (Goyer 1991), but a high frequency of lung tumors was observed in rats exposed by inhalation to antimony trioxide for one year (Elinder and Friberg 1986). The EPA (1991c) has not evaluated the carcinogenicity of antimony.

I.7.6.4 Aroclors

Noncarcinogenic Toxicity

Aroclors-1016, -1221, -1242, -1248, -1254, -1260 are commercially mixtures of polychlorinated biphenyls (PCBs). Target organs for PCBs include the skin, liver, fetus, and neonate. Epidemiologic studies of women in the United States have associated oral PCB exposure with low birth weight or retarded musculoskeletal or neurobehavioral development of their infants (ATSDR 1991). Oral studies in animals have established the liver as the target organ in all species, and the thyroid as an additional target organ in the rat. Effects observed in monkeys included gastritis, anemia, chloracne-like dermatitis, and immunosuppression. Oral exposure in animal models induced developmental effects, including retarded neurobehavioral and learning development in monkeys. Neither verified nor provisional chronic oral RfD values were located for any of the Aroclors.

Occupational exposure to PCBs have been associated with upper respiratory tract and ocular irritation, loss of appetite, liver enlargement, increased serum concentrations of liver enzymes, skin irritation, rashes and chloracne, and in heavily exposed female workers, decreased birth weight of their infants (ATSDR 1991). However, concurrent exposure to contaminants have confounded the interpretation of the occupational exposure studies. Animal models exposed by inhalation to Aroclor-1254 vapors exhibited moderate liver degeneration, decreased body weight gain, and slight renal tubular degeneration. Neither verified nor provisional chronic inhalation RfC values are available.

Carcinogenicity

The EPA (1991c) has classified the PCBs as cancer weight-of-evidence Group B2 substances (probable human carcinogens), based on inadequate data for humans but sufficient data for animals. The human data consists of several epidemiologic occupational and accidental oral exposure studies with serious limitations, including poorly quantified concentrations of PCBs and durations of exposure, and probable exposures to other potential carcinogens (EPA 1992d).

It is known that PCB congeners vary greatly as to their potency in producing biological effects. There is some evidence that mixtures containing more highly chlorinated biphenyls are more

potent inducers of hepatocellular carcinoma in rats than mixtures containing less chlorine by weight (EPA 1993a).

The animal data consists of several oral studies in rats and mice with various Aroclors, Kanechlors or Clophens (commercial PCB mixtures manufactured in the United States, Japan, and Germany, respectively) that reported increased incidence of liver tumors in both species (EPA 1992d). The EPA (1991c) has presented a verified oral slope factor of 7.7 per mg/kg/day for all PCBs, based on liver tumors in rats treated with Aroclor-1260.

I.7.6.5 Arsenic

Noncarcinogenic Toxicity

The only noncarcinogenic effects in humans clearly attributable to chronic oral exposure to arsenic are dermal hyperpigmentation and keratosis, as revealed by studies of several hundred Chinese exposed to naturally occurring arsenic in well water (EPA 1992d). Similar effects were observed in persons exposed to high levels of arsenic in water in the western hemisphere. Occupational (predominantly inhalation) exposure was also associated with neurological deficits, anemia, and cardiovascular effects (Ishinishi et al. 1986). The EPA (1991e) has presented an RfD of 0.0003 mg/kg/day for chronic oral exposure, based on a NOAEL from the Chinese data and an uncertainty factor of 1. The principal target organs for arsenic are the skin, nervous system, blood and cardiovascular system.

Carcinogenicity

Inorganic arsenic is clearly a carcinogen in humans (EPA 1992d). Inhalation exposure was associated with increased risk of lung cancer in persons employed as smelter workers, in arsenical pesticide applicators, and in a population residing near a pesticide manufacturing plant. Oral exposure to high levels in well water was associated with increased risk of skin cancer. The EPA (1991c) has classified inorganic arsenic in cancer weight-of-evidence Group A (human carcinogen). An inhalation slope factor of 50 per mg/kg/day, based on absorbed arsenic, was derived from occupational data. Applying an absorption factor of 0.3 yielded an inhalation slope factor of 15 per mg/kg/day, based on an ambient or inhaled dose. The slope factor based on the inhaled, rather than absorbed, dose is the correct parameter to use in risk assessments. Assuming a human inhales 20 m^3 of air per day and weighs 70 kilograms, the EPA (1991c) estimated an

inhalation unit risk of 0.0043 $\mu g/m^3$. EPA (1993) proposed an inorganic arsenic ingestion unit risk of 5.0×10^{-5} per mg/l. The equivalent oral slope factor is 1.75 per mg/kg/day assuming a 70 kg adult ingests 2 liters per day. "The uncertainties associated with ingested inorganic arsenic are such that estimates could be revised downward as much as an order of magnitude, relative to the risk estimates associated with most other carcinogens.

I.7.6.6 Barium

Noncarcinogenic Toxicity

The acute oral toxicity of barium is manifested by gastrointestinal upset, altered cardiac performance and transient hypertension, and convulsions and muscular paralysis (Reeves 1986). Repeated oral exposures have been associated with hypertension. Occupational exposure to insoluble barium sulfate induced benign pneumoconiosis (ACGIH 1991). The EPA (1993) has derived a verified chronic oral RfD of 0.07 mg/kg/day, based on increased blood pressure in subchronic to chronic human drinking water studies and on an uncertainty factor of 3. A provisional chronic inhalation RfC of 0.0005 mg/m^3 was based on a NOEL for fetotoxicity of 0.8 mg/m^3 in a four-month, intermittent-exposure inhalation study with barium carbonate in the rat, and on an uncertainty factor of 1000 (EPA, HEAST 1992). The equivalent chronic inhalation RfD value is 0.00014 mg/kg/day, assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms. Barium is principally a muscle toxin. Its targets are the gastrointestinal system, skeletal muscle, and the cardiovascular system. The fetus also appears to be a target.

Carcinogenicity

The EPA (1993) reports no data for a carcinogenicity assessment for barium.

I.7.6.7 Beryllium

Noncarcinogenic Toxicity

Beryllium has a low order of toxicity when ingested because it is poorly absorbed from the gastrointestinal tract (Reeves 1986). Occupational exposure has induced dermatitis, acute pneumonitis, and chronic pulmonary granulomatosis (berylliosis). Berylliosis was also observed in humans living in the vicinity of a beryllium plant. Pulmonary effects also occurred in laboratory animals subjected to inhalation exposure. A verified chronic oral RfD value of 0.005 mg/kg/day was based on a NOAEL of 0.54 mg/kg/day in a lifetime drinking water study with beryllium sulfate

in the rat, and on an uncertainty factor of 100 (EPA 1991c). The target organs for inhalation exposure appear to be the lungs; target organs for oral exposure are not identified.

Carcinogenicity

The EPA (1991c) has classified beryllium in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate human data but sufficient animal data. The human data consist of occupational studies that weakly associate exposure with increased risk of lung cancer, but confounding variables were not controlled and the studies lacked sensitivity. A significant increase in lung tumors occurred in three strains of rats and in rhesus monkeys subjected to inhalation exposure or intratracheal instillation of a variety of beryllium compounds. Osteogenic sarcomas were induced in rabbits and mice, but not in rats or guinea pigs injected intravenously with various beryllium compounds. Oral studies in animals models yielded inconclusive results. The EPA (1991c) derived an oral slope factor of 4.3 per mg/kg/day from a slight but statistically nonsignificant increase in total tumors in a lifetime drinking water study with beryllium sulfate in the rat. An inhalation unit risk of 0.0024 per $\mu g/m^3$, equivalent to 8.4 per mg/kg/day (assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms), was derived from a human occupational study.

I.7.6.8 Boron

Noncarcinogenic Toxicity

Acute exposure to boron compounds has been associated with gastrointestinal irritation and central nervous system depression (ACGIH 1991). Occupational exposure induced respiratory tract irritation. Several dietary and drinking water studies with boron (chemical form not specified) in dogs, rats, and mice identified testicular atrophy and impaired spermatogenesis as the critical effect of oral exposure (EPA 1993a). Other effects included reduced body and organ weights, reduced ovulation in female rats, and possibly increased extramedullary hematopoiesis in the spleen. The EPA (1993a) has presented a verified RfD of 0.09 mg/kg/day for chronic oral exposure to boron, based on an NOAEL in a two-year dietary study in dogs (form of boron not specified). An uncertainty factor of 100 was used. The chronic oral RfD was adopted as the provisional subchronic oral RfD (EPA 1992d). The principal target organs of boron are the testis, respiratory mucosa, and central nervous system. The EPA (1992d) has also presented a chronic inhalation RfC of 2×10^{-2} mg/m^3, based on a LOAEL for respiratory tract irritation in a

human study, and on an uncertainty factor of 100. The inhalation RfC is equivalent to 0.0057 mg/kg/day (assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms).

Carcinogenicity

Data were not located regarding the carcinogenicity of boron.

I.7.6.9 Cadmium

Noncarcinogenic Toxicity

The EPA (1991c) has presented verified chronic oral RfD values of 0.0005 mg/kg/day for cadmium ingested in water and 0.001 mg/kg/day for cadmium ingested in food. Medium-specific oral RfD values reflected the assumption that cadmium is more efficiently absorbed from water than from food. The RfD values were based on a NOAEL for proteinuria (a sensitive indicator of renal toxicity), determined from several human exposure studies, and on an uncertainty factor of 10. Occupational exposure to fumes of cadmium induced metal fume fever (ACGIH 1991). The principal target organs for oral exposure to cadmium are the kidneys.

Carcinogenicity

Cadmium is classified as an EPA cancer weight-of-evidence Group B1 substance (probable human carcinogen), based on limited evidence from occupational studies and sufficient evidence of carcinogenicity in rats and mice following inhalation exposure or parenteral injection (EPA 1991c). There is insufficient information to classify cadmium as carcinogenic to humans by the oral route. A provisional inhalation slope factor of 6.3 per mg/kg/day and a unit risk of 0.0018 per $\mu g/m^3$ (assuming inhale 20 m^3 of air per day and humans weigh 70) was based on the incidence of lung cancer in cadmium smelter workers.

I.7.6.10 Carbazole

Noncarcinogenic Toxicity

Only the oral LD_{50} in rats for carbazole has been located. The oral LD_{50} in rats is reported to be greater than 5000 mg/kg (EPA 1993d).

The EPA has not derived chronic oral and chronic inhalation reference doses for carbazole.

Carcinogenicity

The EPA has classified carbazole as a cancer weight-of-evidence Group B2 substance (probable human carcinogen) based on liver tumors in mice administered carbazole in the diet. The EPA has derived an oral cancer slope factor of 2 x 10^{-2} mg/kg/day (1993c).

I.7.6.11 Chromium (VI)

Noncarcinogenic Toxicity

Little chromium (VI) exists in biological materials, except shortly after exposure, because reduction to chromium (III) occurs rapidly (Langård and Norseth 1986). Chromium (III) is considered a nutritionally essential trace element and is considerably less toxic than chromium (VI). Acute oral exposure of humans to high doses of chromium (VI) induces neurological effects, gastrointestinal hemorrhage and fluid loss, and kidney and liver effects. Parenteral dosing of animals with chromium (VI) was selectively toxic to the kidney tubules. A NOAEL of 2.4 mg Cr(VI)/kg/day in a one-year drinking water study in rats with potassium permanganate, along with an uncertainty factor of 500, formed the basis of a verified RfD for chronic oral exposure of 0.005 mg/kg/day (EPA 1991c).

Occupational (inhalation and dermal) exposure to chromium (VI) induced ulcerative and allergic contact dermatitis, irritation of the upper respiratory tract including ulceration of the mucosa and perforation of the nasal septum, and possibly kidney effects (ACGIH 1991). Currently an inhalation RFC and RFD are not available for chromium (VI) from EPA.

Target organs for dermal and inhalation exposure include the skin and respiratory mucosa.

Carcinogenicity

The EPA (1991e) has classified chromium (VI) in cancer weight-of-evidence Group A (human carcinogen), based on the consistent observation of increased risk of lung cancer in occupational studies of workers in chromate production and the chrome pigment industry. Parenteral dosing of animals with chromium (VI) compounds consistently induced injection-site tumors. There is no evidence that oral exposure to chromium (VI) induces cancer. A verified inhalation unit risk of

0.012 per $\mu g/m^3$, equivalent to 41 per mg/kg/day (assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms), was based on increased risk of lung cancer deaths in chromate production workers.

I.7.6.12 Cobalt

Noncarcinogenic Toxicity

Acute, high oral or parenteral doses of cobalt in humans and animals induced myocardial degeneration, often leading to mortality, erythropoiesis, enlarged thyroid, and in animals, renal tubular degeneration (Elinder and Friberg 1986). Chronic ingestion from the consumption of beer containing high concentrations of cobalt has been associated with a condition called "beer-drinkers cardiomyopathy," which includes polycythemia, goiter, and marked myocardial degeneration and mortality. The therapeutic use of 0.16 to 0.32 mg Co/kg/day in anemic, anephric dialysis patients for 12 to 32 weeks induced a significant but reversible rise in blood hemoglobin concentration (EPA 1992d).

Occupational (inhalation and dermal) exposure has been associated with allergic dermatitis, chronic interstitial pneumonitis, reversibly impaired lung function, occupational asthma, and myocardial effects (ACGIH 1991). Cobalt has been determined to be the etiologic factor in hard metal disease, the syndrome of respiratory symptoms and pneumoconiosis associated with inhalation exposure to dusts containing tungsten carbide with cobalt powder as a binder (Elinder and Friberg 1986). The lowest occupational air concentration of cobalt associated with hard metal disease was 0.003 mg Co/m^3 (Sprince et al. 1988). It should be noted that the workers were also exposed to tungsten and sometimes to titanium, tantalum, and niobium (Elinder and Friberg 1986). Similar lung effects have been seen in animals exposed to cobalt by inhalation.

The developmental toxicity of cobalt was tested in rodents treated orally with cobalt chloride (EPA 1992c). Unspecified maternal effects were reported in rats treated with 5.4 to 21.8 mg Co/kg/day from gestation day 14 through lactation day 21. Effects on the offspring included stunted growth at 5.4 mg Co/kg/day and reduced survival at 21.8 mg Co/kg/day. In rats treated with 6.2, 12.4 or 24.8 mg Co/kg/day on gestation days 6 through 15, maternal effects included reduced food consumption and body weight gain and altered hematologic parameters, although it is unclear at what dose levels these effects occurred. There were no effects on fetal survival,

although an insignificant increase in fetal stunting was observed in rats treated with ≥12.4 mg Co/kg/day. In mice, treatment with 81.7 mg Co/kg/day caused reduced maternal weight gain, but had no fetal effects.

Several studies reported testicular degeneration and atrophy in rats treated with cobalt chloride in the diet or drinking water at concentrations equivalent to doses of 5.7 to 30.2 mg Co/kg/day (EPA 1992c).

Cobalt is nutritionally essential as a cofactor in cyanocobalamin, i.e., vitamin B12 (EPA 1992c). The element is ubiquitous and universally present in the diet. Average daily adult dietary intakes of cobalt range from 0.16 to 0.58 mg/day (0.002 to 0.008 mg/kg/day, assuming adults weigh 70 kilograms) (Tipton et al. 1966; Schroeder et al. 1967). In 9- to 12-year-old children, dietary intakes of cobalt range from 0.3 to 1.77 mg/day (Murthy et al. 1971; NRC 1989). Assuming an average weight for children in this age range of 28 kilograms (NRC 1989), the dietary intakes are equivalent to 0.01 to 0.06 mg/kg/day.

The EPA (1992g) concluded that the oral toxicity data were insufficient to derive an oral RfD for cobalt. The relatively well-characterized dietary intake data, however, can provide useful guidance. The EPA noted that the upper range of dietary intake for children, 0.06 mg/kg/day, was below the level associated with enhanced erythropoiesis in anephric patients. Therefore, the upper range of dietary intake, 0.06 mg Co/kg/day, can be considered a guidance level for the oral intake of cobalt and can be used in place of an oral RfD in CERCLA and RCRA risk assessments.

The EPA (1990i) has derived an interim inhalation RfC from the LOAEL of 0.003 mg Co/m^3 associated with hard metal disease in occupationally exposed humans. Correcting for intermittent occupational exposure (10 m^3 of air inhaled per work day/20 m^3 of air inhaled per day x 5 work days per week/7 days per week) yielded an adjusted LOAEL of 0.001 mg/m^3. Applying an uncertainty factor of 1000 (10 for use of a LOAEL, 10 to protect sensitive individuals, and 10 to account for the disparity between the latency period and exposure duration — not further explained) resulted in an interim chronic RfC of 1×10^{-6} mg/m^3. Assuming humans inhale 20 m^3

of air per day and weigh 70 kilograms, the RfC is equivalent to 2.9 x 10^{-7} mg/kg/day, rounded to 3 x 10^{-7} mg/kg/day.

Important target organs in orally exposed humans are the heart, erythrocyte, and thyroid. Target organs for occupational exposure are the skin, lungs, and heart.

Carcinogenicity

The carcinogenicity of cobalt has not yet been evaluated by the EPA (1992b, 1992c).

I.7.6.13 Copper

Estimates of the absorption of copper from the gastrointestinal tract range from 15 to 97 percent, with an average of approximately 60 percent (ATSDR 1989d). Several factors, including the dose of copper, the presence of other metals in the diet, the form of copper administered, and the presence of substances that inhibit uptake (vitamin C, phytate, fiber), influence the extent of gastrointestinal absorption. The 15-percent estimate is considered sufficiently conservative and well-documented for use in estimating the dermal RfD from an oral RfD.

Quantitative data were not located regarding the uptake of copper from the respiratory tract. The observation of elevated plasma copper levels in some workers in a heavily polluted industrial atmosphere indicated respiratory tract uptake does occur (Aaseth and Norseth 1986). Data were not located regarding the dermal uptake of copper.

Circulating copper is taken up by the liver, transferred to the ceruloplasmin, (high molecular weight protein), reenters the circulation, and accumulates in liver, heart, brain, kidneys, and muscles (Aaseth and Norseth 1986). Excretion is principally through the bile.

Noncarcinogenic Toxicity

Copper is a nutritionally essential element that functions as a cofactor in several enzyme systems (Aaseth and Norseth 1986). Acute exposure to large oral doses of copper salts has been associated with gastrointestinal disturbances, hemolysis, and liver and kidney lesions. Chronic oral toxicity in humans has not been reported. Chronic oral exposure of animals has been associated with an iron-deficiency type of anemia, hemolysis, and lesions in the liver and kidneys.

Occupational exposure has induced metal fume fever, and in cases of chronic exposure to high levels, hemolysis and anemia (ACGIH 1991). Neither oral nor inhalation RfD or RfC values were available for copper from the US EPA. The target organs for copper are the erythrocyte, liver, and kidneys, and for inhalation exposure, the lung.

The EPA (1992) has concluded that the health effects data were inadequate for deriving a chronic oral RfD for copper. The current drinking water maximum contaminant level goal (MCLG) for copper is 1.3 mg/l, which was based on an LOAEL for gastrointestinal effects in acutely exposed humans, and an uncertainty factor of 2. The MCLG is equivalent to a daily intake from water of 2.6 mg/day, assuming a drinking water ingestion rate of 2 l/day. The MCLG of 1.3 mg/l is an inappropriate basis for deriving a toxicity value for use in a CERCLA risk assessment, for three main reasons:

1. The MCLG is based on the effects resulting from acute exposure, and it is not reasonable to assume that a toxicity value designed to protect against effects from short-term exposure would sufficiently protect against effects from chronic exposure.

2. The estimated safe and adequate daily dietary intake of copper for adults is 1.5 to 3.0 mg/day (NRC 1989), which exceeds the equivalent daily intake from drinking water estimated from the MCLG.

3. The estimated adult daily intake of copper from food is 2.0 to 4.0 mg/day (EPA 1985a), which also exceeds the equivalent daily intake from drinking water estimated from the MCLG.

Carcinogenicity

Copper is in cancer weight-of-evidence Group D, meaning it is not classifiable as to human carcinogenicity (EPA 1992c). Quantitative risk estimates are not derived from Group D chemicals.

I.7.6.14 Cyanide

Noncarcinogenic Toxicity

Acute exposure to cyanide induces histotoxic hypoxia (inability of the tissues to use oxygen); death is due to central respiratory arrest (Smith 1991). Chronic dietary exposure to cyanide has induced reduced body weight gain, decreased thyroid activity, myelin degeneration, and reduced

fertility in rats (EPA 1992d). The EPA (1993) has presented a verified RfD of 0.02 mg/kg/day for oral exposure to cyanide, based on a NOAEL in a two-year study of rats that consumed food fumigated with hydrogen cyanide, and on an uncertainty factor of 100. The target organs for chronic oral exposure to cyanide appear to be the thyroid and nervous system.

Carcinogenicity

The EPA (1991c) classified cyanide as a cancer weight-of-evidence Group D substance (not classifiable as to humans carcinogenicity).

I.7.6.15 Dioxin/Furan

No data were located regarding the pharmacokinetics of the polychlorinated dibenzo-p-dioxins (PCDDs) or (PCDFs) of concern; however, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) has been used as a surrogate for other structurally similar members of these chemical classes. Estimates of the gastrointestinal absorption of TCDD ranged from 50 to 86 percent of the administered dose in rats; comparable data were obtained for rates and hamsters (Fries and Morrow 1975; Nolan et al. 1979; Olson et al. 1986). In rats treated dermally with 26 ng TCDD in methanol dermal absorption after 24 hours approximated 40 percent of that absorbed by the gastrointestinal tract after an equivalent dose in ethanol (Poiger and Schlatter 1980). Dermal absorption from vaseline or polyethylene glycol vehicles was substantially less than from methanol, but quantitative estimates cannot be made from the available data.

In rodents given single oral or intrapeitonel doses, or treated for two years with TCDD in the diet, the highest concentrations and greatest tissue depots occurred in the liver, followed closely by adipose tissue (Piper et al. 1973; Poiger and Schlatter 1979; Rose et al. 1976; Kociba et al. 1976). Concentrations in other tissues were considerably lower than those in fat. Mouse liver continued to sequester TCDD more efficiently with prolonged exposure (Teitelbaum and Poland 1978). In nonhuman primates and guinea pigs, however, greater TCDD concentrations and tissue depots occurred in the adipose tissue than in the liver (Nolan et al. 1979; Van Miller et al. 1976). Data obtained at necropsy from one woman potentially exposed to TCDD showed concentrations in adipose tissue about an order of magnitude higher than levels in the liver (Facchetti et al.

1980). Radioactivity from intravenous dosing with [^{14}C]2,3,7,8-TCDD has been shown to cross the placenta of rats and mice; concentrations of fetal tissues were lower than in maternal tissues (Moore et al. 1976; Nau and Bass 1981).

In rodents and guinea pigs, TCDD was metabolized by microsomal mixed-function oxidase enzymes to hydroxylated derivatives that were conjugated with glucuronide or sulfate for excretion via the bile or urine, respectively (Neal et al. 1982; Olson and Bittner 1983). The hydroxylation of several different PCDDs in the rat was postulated to involve formation of arene oxide intermediates (EPA 1985a). In rats, the metabolism of TCDD was inducible but relatively slow, about four orders of magnitude slower than the metabolism of benzo(a)pyrene. There was considerable species variation in the rate of metabolism of TCDD.

Studies with [^{14}C],-2,3,7,8-TCDD showed that fecal excretion accounted for 39 to 99 percent of the total (fecal and urinary) excretion of radioactivity (EPA 1985a). Elimination half-lives (assuming first order kinetics) ranged from 11 to 30 days, inversely correlated with species sensitivity to TCDD. There was considerable interspecies variation in the relative importance of fecal versus urinary excretion and in the elimination half-lives.

Noncarcinogenic Toxicity

The only effect in humans clearly attributable to TCDD was chloracne (ATSDR 1989b). The available data, however, also associated exposure to TCDD with hepatotoxicity and neurotoxicity in humans. In animals, TCDD toxicity is most commonly manifested as a wasting syndrome with thymic atrophy terminating in death, with a large number of organ systems showing nonspecific effects. Chronic treatment of animals with TCDD or a mixture of two isomers of hexachlorodibenzo-p-dioxin resulted in liver damage. Immunologic effects may be among the more sensitive endpoints of exposure to the PCDDs in animals. TCDD is a developmental and reproductive toxicant in animal models. Data were not located regarding the noncarcinogenic toxicity of unsubstituted dibenzofuran or the other PCDFs. No verified or provisional noncarcinogenic toxicity values were located for any of the chemicals of concern in these classes (EPA 1992b, 1992c).

Carcinogenicity

The EPA (1992b) has verified dibenzofuran as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans), based on a lack of cancer data in humans or animals. Data regarding the humans carcinogenicity of TCDD obtained from epidemiologic studies of workers exposed to pesticides or to other chlorinated chemicals known to be contaminated with TCDD, are conflicting (ATSDR 1989b). The interpretation of these studies is clouded, because exposure to TCDD was not quantified, multiple routes of exposure (dermal, inhalation, oral) were involved, and the workers were exposed to other potentially carcinogenic compounds. TCDD, however, is clearly carcinogenic in animal models, inducing thyroid, lung, and liver tumors in orally treated rats and mice (EPA 1985a). Similarly, oral treatment with a mixture of two hexachlorodibenzo-p-dioxin isomers induced liver tumors in rats and mice. On the basis of the animal data, TCDD and the hexachlorodibenzo-p-dioxins were assigned to EPA cancer weight-of-evidence Group B2 (probable human carcinogen). Although the PCDDs and PCDFs of concern were not classified, they are treated as probable human carcinogens, for which slope factors are derived.

The EPA (1992b) has presented provisional oral and inhalation slope factors for TCDD of 150,000 per mg/kg/day, based on the incidence of liver and lung tumors in an oral study in rats (Kociba et al. 1978). In the absence of satisfactory congener-specific cancer data, the EPA (1989g) derived toxicity equivalency factors (TEFs) for the other PCDDs and PCDFs, by assuming that all manifestations of toxicity for all members of these classes are mediated by a common mechanism (i.e., binding to the intraculluar AH receptor of target cells). For polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofurans; 2,3,7,8-TCDD toxicity equivalents will be calculated using the appropriate 1-TEFs/89 Toxicity Equivalent Factors (EPA 1989g). Table I.7-5 presents the TEFs developed by EPA.

Considerable uncertainty surrounds the carcinogenic potential of the PCDDs and PCDFs of concern. Although TCDD is classified as a weight-of-evidence Group B2 substance, the homologues of concern are not classified. The appropriateness of estimating cancer potency of (i.e., regulating as carcinogens) compounds not assigned to a cancer weight-of-evidence group is questionable (EPA 1986b).

TABLE I.7-5

DIOXIN AND FURAN TOXICITY EQUIVALENCY FACTORS

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 (PeCDDs)	0.5
Other PeCDDs	0
2,3,7,8-Hexachlorodibenzo-p-dioxins (HxCDDs)	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-, and 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-furans (HxCDFs)	0.1
Other HxCDFs	0
2,3,7,8-Heptachlorodibenzo-p-furans (HpCDFs)	0.01
Other HpCDFs	0
Octachlorodibenzo-p-furan (OCDF)	0.001

SOURCE: EPA 1989h

There is uncertainty about the slope factor for TCDD. Additional uncertainty is introduced by the use of the TEFs themselves, most of which were derived not from cancer data, but from in vitro data such as enzyme induction, which is only hypothetically related to a carcinogenic role. For example, the TEF of 0.001 for octachlorodibenzo-p-dioxins (OCDDs) and octachlorodibenzofurans (OCDFs) is based on the appearance of "dioxin-like" effects and detectable levels of OCDD late in a 13-week study of male rats treated with OCDD (Couture et al. 1988) and on in vitro evidence of enzyme induction (EPA 1989g). Before the Couture et al. (1988), paper was available, the TEF for these homologues, based on limited in vivo and in vitro data, was 0.0.

I.7.6.16 Endrin

Noncarcinogenic Toxicity

Chronic oral exposure studies with endrin have been conducted using the dog and rat animal models.

Groups of 3 to 7 dogs/sex were fed diets containing 0.1, 0.5, 1.0, 2.0 or 4.0 ppm endrin for 2 years. Dogs receiving 2 or 4 ppm experienced occasional convulsions, slightly increased relative liver weights, and mild histopathological effects in the liver (slight vacuolization of hepatic cells). No adverse effects on these parameters or on growth, food consumption, behavior, serum chemistry, urine chemistry, or histological appearance of major organs occurred at 1 ppm (NOEL) or less. The 1 ppm NOEL was equivalent to an endrin intake of 0.025 mg/kg/day. The 2 ppm level is he LOAEL.

An earlier study established a dietary NOEL of 1 ppm for both dogs and rats for long-term feeding (18 months to 2 years). LOAELs of 3 ppm and 5 ppm were reported for dogs and rats, respectively. The primary target organs were the kidneys and liver. Dogs are judged to be more sensitive than rats to long-term exposure to endrin because of the dogs lower food consumption and because of the dogs, much shorter duration of exposure (in this study) relative to their lifetime.

The EPA has derived a chronic oral RfD of 3×10^{-4} mg/kg/day based on animal studies in which endrin was administered in the diet, and an uncertainty factor of 100 (EPA 1994a).

Carcinogenicity

The EPA has classified endrin as a cancer weigh-of-evidence Group D substance, i.e., not classifiable as to human carcinogenicity (EPA 1994b). Oral administration of endrin did not produce carcinogenic effects in either sex of two strains of rats and three strains of mice.

In an epidemiological study, vital status and cause of death were assessed for 232 of 233 workers engaged in the manufacturing and/or formulation of aldrin, dieldrin, and endrin. This group was selected due to the high exposures in the initial years of manufacturing and formulation, and the long exposure (mean 11 years) and observation (mean 24 years) periods. Total observed mortality was 25 versus 38 expected on the basis of the death statistics of the male Dutch population. Of the 9 cancer deaths, 3 were caused by lung cancer, while the remaining 6 were each different. Although in this group exposures have been high, and exposure and observation period long enough for meaningful evaluation, this study revealed no indication of a specific carcinogenic activity of aldrin, dieldrin, or endrin in manufacturing plant workers exposed to these products (EPA 1993d).

I.7.6.17 Lead

Noncarcinogenic Toxicity

The noncarcinogenic toxicity of lead has been well characterized through decades of medical observation and scientific research (EPA 1993a). The primary effects of long-term exposure to levels expected to be encountered in the environment are neurological and hematological. Some of the effects on the blood, particularly changes in levels of certain blood enzymes, and subtle neurobehavioral changes in children appear to occur at levels so low as to be considered nonthreshold effects. In part for this reason the RfD/RfC Work Group considered inappropriate the derivation of an RfC or RfD for inhalation exposure, or an RfD for oral exposure (EPA 1993a). The principal target organs of lead are the central nervous system and the hematopoietic system.

The EPA has developed an uptake/biokinetic model to predict blood lead levels in populations exposed to lead in air, diet, drinking water, indoor dust, soil and paint. This makes it possible to evaluate the effects of regulatory decisions concerning each medium on blood lead levels and potential health effects. The model is used to estimate lead uptake and subsequent blood lead

levels in young children, who are the most sensitive subpopulation for exposure to lead. It accepts user input of variables pertaining to site-specific exposure to lead through air, diet, water, soil, dust, and paint (EPA 1990h). In the absence of data on site-specific residential exposure variables, this model is not applicable to the Operable Unit 1&2 CRARE.

OSWER Directive No. 9355.4-02 (EPA 1989u) established a soil cleanup level for lead of 500 to 1000 ppm, based on recommendations by the Centers for Disease Control designed to protect children from blood lead concentrations above background, which are associated with lead-induced neurological effects. In the absence of current measures of residential exposure and other site-specific variables, the OSWER directive (EPA 1989u) appears to be the soundest and most defensible basis for evaluating the toxicity of exposure to lead in soil.

Carcinogenicity

Lead is assigned to cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate human evidence but sufficient animal evidence (EPA 1993a). Rat and mouse bioassays have shown statistically significant increases in renal tumors following dietary and subcutaneous exposure to several soluble lead salts. The EPA has declined to quantitatively estimate risk for oral exposure to lead because many factors (i.e., age, general health, nutritional status, existing body burden, and duration of exposure) influence the bioavailability of ingested lead, introducing a great deal of uncertainty into any estimate of risk.

I.7.6.18 Manganese

Noncarcinogenic Toxicity

The EPA (1993) has presented a verified chronic (food) oral RfD of 0.14 mg/kg/day of manganese, based on a NOEL for humans in chronic dietary intake studies and an uncertainty factor of 1, plus a chronic oral (water) RfD of 0.005 mg/kg/day based on a NOEL for humans in a chronic water ingestion study and an uncertainty factor of 1. The EPA (1993) has also presented a chronic inhalation RfC of 0.0004 mg/m^3, based on a LOAEL for psychomotor disturbances and respiratory symptoms in occupationally exposed humans, and on an uncertainty factor of 300. The inhalation RfC is equivalent to 0.00011 mg/kg/day (assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms. The central nervous system and respiratory tract are the target organs of inhalation exposure to manganese.

Carcinogenicity

The EPA (1993) has classified manganese in cancer weight-of-evidence Group D (not classifiable as to human carcinogenicity).

I.7.6.19 Mercury

Noncarcinogenic Toxicity

Acute oral exposure to high doses of inorganic mercury causes severe damage to the gastrointestinal mucosa, which may lead to bloody diarrhea, shock, circulatory collapse, and death (Berlin 1986). Acute sublethal poisoning induces severe kidney damage, while chronic exposure induces an autoimmune glomerular disease and renal tubular injury. The EPA (1991c) has presented a verified RfD of 0.0003 mg/mg/day for chronic oral exposure to inorganic mercury, based on kidney effects in rats and an uncertainty factor of 1000. The form of mercury used in these studies was not described. Occupational exposure has induced neurotoxicity (Berlin 1986). The EPA (1991c) has also presented a verified chronic inhalation RfC of 0.0003 mg/m^3, based on occupational data and an uncertainty factor of 30. The RfC is equivalent to 8.6×10^{-5} mg/kg/day (assuming humans inhale 20 m^3 of air per day and weigh 70 kilograms). Target organs for inorganic mercury include the gastrointestinal tract, the central nervous system and kidneys.

Carcinogenicity

The EPA (1991c) has classified mercury in cancer weight-of-evidence Group D (not classifiable as to humans carcinogenicity).

I.7.6.20 Molybdenum

Molybdenum is a nutritionally essential trace element (Friberg and Lener 1986). Its most important oxidation states are +2, +3, +4, and +6.

Pharmacokinetics

Molybdenum from soluble compounds is readily absorbed from the gastrointestinal or respiratory tracts (Friberg and Lener 1986). Estimates of gastrointestinal absorption in humans average around 50 percent, with a range of 38 to 72 percent observed in young women, and 77 percent reported for school children. The form or oxidation state of molybdenum used in these studies was not specified. Estimates of gastrointestinal absorption in laboratory animals have ranged from

40 to 85 percent for hexavalent molybdenum. The 38 percent estimate of gastrointestinal absorption is considered sufficiently conservative and well-documented for use in estimating a dermal RfD from an oral RfD.

Inhalation uptake studies with guinea pigs showed that molybdenum disulfide was essentially unabsorbed, but that hexavalent molybdenum was absorbed to an appreciable (unquantified) extent (Friberg and Lener 1986).

Absorbed molybdenum was distributed primarily to the kidneys, liver, and bone in several animal models (Friberg and Lener 1986). Molybdenum appears to accumulate in the liver, cartilage of the long bones, and skin. In humans and most animal models, the kidneys are the principal organs of excretion. The excretion of molybdenum is affected by the level of copper and sulfate in the diet.

Noncarcinogenic Toxicity

Chronic molybdenum poisoning in livestock (teart) has resulted from a molybdenum-copper imbalance and is characterized by anemia, gastrointestinal disturbances, bone disorders, and growth depression (Friberg and Lener 1986). In laboratory animals, excess molybdenum has induced effects in the liver, kidneys, and spleen. Gout-like symptoms were observed in humans living in a high-molybdenum, low-copper area. A few cases of pneumoconiosis were reported in occupationally exposed workers. The EPA (1992b) has derived a provisional chronic oral RfD of 0.005 mg/kg/day, based on an LOAEL in humans exposed to high levels in water and diet, and on an uncertainty factor of 30. The effects of concern were increased urinary excretion of uric acid, decreased copper levels in the blood, and pain and swelling in the joints. Target organs for molybdenum toxicity include the erythrocyte, joints, liver, and kidneys.

Carcinogenicity

No information was located regarding the carcinogenicity of molybdenum.

I.7.6.21 Nickel

Noncarcinogenic Toxicity

The EPA (1991e) has presented a verified RfD of 0.02 for chronic oral exposure to nickel, based on a NOAEL for decreased organ and body weights in a two-year dietary study with nickel sulfate in rats. An uncertainty factor of 300 was used. In a subchronic study with nickel chloride in water, clinical signs of toxicity included lethargy, ataxia, irregular breathing, reduced body temperature, salivation, and discolored extremities (EPA 1992b). These clinical signs suggest the central nervous system may be a target for the toxicity of nickel.

Carcinogenicity

Occupational exposure to nickel has been associated with increased risk of nasal, laryngeal, and lung cancer (ATSDR 1988). Rats inhaling nickel subsulfide increased their incidence of lung tumors. The EPA (1991e) has assigned nickel to cancer weight-of-evidence Group A (human carcinogen) and for nickel refinery dust has presented an inhalation slope factor of 0.84 per mg/kg/day and an inhalation unit risk of 0.00024 per $\mu g/m^3$. The quantitative estimates were derived from the human occupational studies.

I.7.6.22 Selenium

Noncarcinogenic Toxicity

Selenium is a nutritionally essential trace element that is an integral part of the enzyme glutathione peroxidase and other proteins (Högberg and Alexander 1986). NRC (1989) recommended dietary allowances (RDAs) for humans range from 10-75 μg/day. Chronic ingestion of 5 mg/day (0.071 mg/kg/day, assuming humans weigh 70 kilograms) induced selenosis in humans, characterized by abnormal hair and nail formation (Högberg and Alexander 1986). Effects in domestic grazing animals exposed to high levels of selenium included emaciation, lameness, and loss of hair and hooves. The EPA (1991c) has derived a verified RfD of 0.005 mg/kg/day for chronic oral exposure to selenium, based on effects in humans exposed to selenium in high selenium areas. An uncertainty factor of 15 was used. The principal target organs for selenium are the skin, including the nails and hair, and in animals, the hooves and joints.

Carcinogenicity

An impressive body of data indicates that selenium exerts an anticarcinogenic effect (Högberg and Alexander 1986). In laboratory animals, selenium supplementation decreased the incidence of chemical-induced cancers. In humans, the incidence of lymphomas and cancers of the breast, digestive tract, and lungs were lower in geographic areas with high soil selenium levels. Occupational data suggest that selenium may protect against lung cancer. Several animal tests with various deficiencies in design and conduct equivocally associated exposure to selenium with cancer induction. In a well-controlled oral experiment, selenium sulfide was associated with an increase in the incidence of liver tumors in rats, and with liver and lung tumors in mice. On the basis of this study, the EPA (1991c) has assigned selenium sulfide to cancer weight-of-evidence Group B2 (probable human carcinogen). Quantitative risk estimates were not derived.

I.7.6.23 Silver

Pharmacokinetics

The gastrointestinal absorption of ingested silver in animals has been estimated at 10 percent or less; however, absorption of 18 percent was estimated for one person given silver acetate (Fowler and Nordberg 1986). Highest tissue levels are located in the liver; lower levels are located in the lungs, brain, spleen, bone marrow, muscle, and skin (Fowler and Nordberg 1986; Goyer 1991). Excretion is virtually entirely through the bile. The excretion kinetics appear to be species- and organ-dependent. In humans, the apparent half-life for silver in the liver is approximately 50 days. Silver in skin also appears to have a long half-live (not quantified).

Noncarcinogenic Toxicity

Silver compounds have been used in dentistry, medicinally in the treatment of burns, as a local disinfectant, and as a drinking-water disinfectant (Fowler and Nordberg 1986). The classical syndrome of toxicity, called argyria, is a blue-gray to nearly black discoloration of areas of the skin or the viscera resulting from deposition of microscopic granules of silver compounds in the affected tissues. Argyria results from occupational (inhalation), parenteral, or oral exposure. The EPA (1993a) has derived an RfD of 0.005 mg/kg/day for chronic oral exposure, based on an LOAEL for argyria in a two- to nine-year intravenous administration study in humans, and an uncertainty factor of 3.

Carcinogenicity

The EPA (1993a) has assigned silver to cancer weight-of-evidence Group D (not classifiable as to human carcinogenicity). The human data show no evidence in the literature of cancer despite frequent medical use of silver compounds. The animal data are limited to studies of implanted silver foil or injected metallic silver that provide unconvincing indications of a carcinogenic response relevant to humans.

I.7.6.24 Thallium, Soluble Salts

Noncarcinogenic Toxicity

Thallium is highly toxic; acute ingestion in humans or laboratory animals induces gastroenteritis, neurological dysfunction, and renal and liver damage (Kazantzis 1986). Chronic ingestion of more moderate doses characteristically causes alopecia. Thallium was once used medicinally to induce alopecia in cases of ringworm of the scalp, sometimes with disastrous results. In industrial exposure (inhalation, oral, dermal), neurologic signs precede alopecia, suggesting that the nervous system is more sensitive than the hair follicle. The EPA (1991c) has derived a chronic oral RfD of 8×10^{-5} mg/kg/day based on increased incidence of alopecia and increased serum levels of liver enzymes indicative of hepatocellular damage in rats treated with thallium sulfate for 90 days. An uncertainty factor of 3000 was used. Chronic oral RfDs have also been developed for thallium acetate, thallium carbonate, thallium selenite, thallium chloride and thallium mononitrate based on the study performed with thallium sulfate. These oral RfDs are calculated by analogy to thallium sulfate by correcting for molecular weight differences. These RfDs range from 8×10^{-5} to 9×10^{-5} mg/kg/day. Target organs for thallium include the gastrointestinal tract (acute exposure), central nervous system, skin, kidneys and liver.

Carcinogenicity

The EPA (1991c) has assigned several thallium compounds (thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, and thallium sulfate) to cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans).

I.7.6.25 Vanadium

Noncarcinogenic Toxicity

The oral toxicity of vanadium and its compounds to humans is very low (Lagerkvist et al. 1986), probably because little vanadium is absorbed from the gastrointestinal tract. Effects in humans exposed by inhalation include upper and lower respiratory tract irritation. A provisional chronic oral RfD of 0.007 mg/kg/day was derived from a NOEL in the rat in a lifetime drinking water study with vanadyl sulfate, and from an uncertainty factor of 100 (EPA 1991c). A target organ could not be identified for oral exposure, but the respiratory tract is the target organ for inhalation exposure.

Carcinogenicity

No information was located regarding the carcinogenicity of vanadium.

I.7.6.26 Zinc

Noncarcinogenic Toxicity

Zinc is a nutritionally essential trace element required for the proper function of many metalloenzymes and DNA polymerase, which is required for cell division (Elinder 1986). Acute oral exposure to high doses induces gastrointestinal irritation, while chronic oral toxicity may be manifested as anemia, resulting from impaired gastrointestinal absorption of copper. The inhalation of dust or vapor by occupationally exposed humans has induced pneumonitis and metal fume fever. A chronic oral RfD for zinc of 0.3 mg/kg/day was based on a LOAEL for a decrease in erythrocyte superoxide dismutase in adult female humans after a 10 week zinc diet supplement study and on an uncertainty factor of 3 (EPA 1991c). The primary target organs for zinc include the gastrointestinal tract for oral exposure and the lungs for inhalation exposure.

Carcinogenicity

The EPA (1991c) has assigned zinc to cancer weight-of-evidence Group D (not classifiable as to human carcinogenicity).

I.8.0 QUANTIFICATION OF CONTAMINANT EXPOSURE AND INTAKE

This section defines the quantification methods used for evaluating cancer risks and the potential for adverse noncancer health effects. Minimum and maximum results calculated for intake of COCs contributing to the calculated risks are presented at the end of this section.

I.8.1 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.

I.8.2 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:

$$CDI = \frac{C \times CR \times EFD}{BW} \times \frac{1}{AT} \qquad (1)$$

where

CDI	=	chronic daily intake (mg/kg body weight/day),
C	=	chemical concentration in exposure medium (mg/l),
CR	=	contact rate with exposure medium (l/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 incremental lifetime cancer risk (ILCR), and 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 as described in Section I.7.2. 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 EPA (1989l) and the RAWPA. The intake equations follow.

Inhalation:

$$I\ (pCi) = C \times IR \times ED \times EF \times ET \qquad (2)$$

Ingestion of soils, liquids and products:

$$I\ (pCi) = C \times IR \times ED \times EF \times FI \qquad (3)$$

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 (hours/day),
EF	=	exposure frequency (days/year), and
ED	=	exposure duration (years).
FI	=	fractional intake

CDI and I are analogous chronic intakes for chemicals and radionuclides, respectively.

The exposure pathways used to assess receptor contaminant intakes and doses are discussed in Section I.5.2. The exposure parameters and factors used are summarized in Tables I.8-1 and 8-2. The exposure parameters were based on those used in the Operable Unit 2 RI report. Specifically, the receptor intakes of COCs were quantified using the methods, models, and parameters specified in the RAWPA (DOE 1992i) and in the SWCR (DOE 1993e) with one exception. The soil ingestion rate used for the groundskeeper was 100 mg/day, consistent with the value used in the Operable Unit 4 RI report. This deviation is the direct result of FERMCO's response to EPA Region V review comments on the SWCR.

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 0.2g/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 0.48g/day of soil (a total of 2400 grams). During the remaining 250 days a year spent on the property, the resident ingests soil at a rate of 0.1g/day - adding another 1,250 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 0.1g/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 0.18g/day (180 mg/day).

I.8.3 RESULTS OF INTAKE QUANTIFICATION

Table I.8-3 presents the minimum and maximum calculated intake of COCs for all viable exposure pathways for the Current Land Use scenario. Tables I.8-4 and I.8-5 present the same information for the two Future Land Use scenarios (with and without federal ownership). All exposure calculations were carried through the CDI or exposure step for all COCs. These tables present the minimum and maximum calculated intakes for only those COCs contributing to the calculated risks. The tables in Attachment I.IV present all CDIs whether or not toxicity factors (RfDs, RfCs, and cancer slope factors) were available. The summary tables do not carry forward the CDIs for COCs without toxicity factors. However, the uncertainty analysis in Section I.10.0 covers the impact of these chemicals. Attachment I.IV presents the intake and calculation worksheets. These intake estimates are used in Section I.9.0, in conjunction with contaminant toxicity data (from Section I.7.0), to quantify the risks resulting from exposures.

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TABLE I.8-1

PARAMETERS USED IN CRANE TO ESTIMATE COC EXPOSURES FOR CURRENT AND FUTURE LAND USE SCENARIOS[a]

	RME Receptor								
		On-Property Resident Farm			Off-Property Resident Farm		Trespassing	Expanded Trespasser[b]	
								Childhood	Adulthood
Exposure Pathway	Groundskeeper	Adult(GMA)	Adult(P)	Child	Adult	Child	Child[b]	Years	Years
Inhalation of Dusts and Radon									
IR (m^3/hr)	2.5	0.83	0.83	0.5	0.83	0.5	0.83	0.83	0.83
ET (hr/d)	8	24	24	24	24	24	4	2	1
EF (d/yr)	250[c]	350	350	350	350	350	52	110	40
ED (yr)	25	70	70	6	70	6	12	12	32
BW (kg)	70	70	70	15	70	15	43	43	70
AT Noncancer (d)	9125	25550	25550	2190	25550	2190	4380	4380	11680
AT Cancer (d)	25550	25550	25550	25550	25550	25550	25550	25550	25550
Drinking Water									
IR (l/d)	NA	2	2	1	2	1	NA	NA	NA
FI (unitless)	NA	1	1	1	1	1	NA	NA	NA
EF (d/yr)	NA	350	350	350	350	350	NA	NA	NA
ED (yr)	NA	70	70	6	70	6	NA	NA	NA
BW (kg)	NA	70	70	15	70	15	NA	NA	NA
AT Noncancer (d)	NA	25550	25550	2190	25550	2190	NA	NA	NA
AT Cancer (d)	NA	25550	25550	25550	25550	25550	NA	NA	NA
Incidental Ingestion while Wading									
IR (l/hr)	NA	NA	NA	NA	NA	NA	0.035	0.035	NA
FI (unitless)	NA	NA	NA	NA	NA	NA	1	1	NA
ET (hr/d)	NA	NA	NA	NA	NA	NA	1.0	1.0	NA
EF (d/yr)	NA	NA	NA	NA	NA	NA	7[c]	52	NA
ED (yr)	NA	NA	NA	NA	NA	NA	12	12	NA
BW (kg)	NA	NA	NA	NA	NA	NA	43	43	NA

See footnotes at end of table.

TABLE I.8-1
(Continued)

	RME Receptor								
		On-Property Resident Farm			Off-Property Resident Farm		Trespassing	Expanded Trespasser[b]	
								Childhood	Adulthood
Exposure Pathway	Groundskeeper	Adult(GMA)	Adult(P)	Child	Adult	Child	Child[b]	Years	Years
Incidental Ingestion while Wading (Continued)									
AT Noncancer (d)	NA	NA	NA	NA	NA	NA	4380	4380	NA
AT Cancer (d)	NA	NA	NA	NA	NA	NA	25550	25550	NA
Incidental Ingestion of Soil/Sediment									
IR (mg/d)	100	180	180	200	NA	NA	100	100	100
FI	1	1	1	1	NA	NA	.25	.125	.125
EF (d/yr)	250[c]	350	350	350	NA	NA	52	110	40
ED (yr)	25	70	70	6	NA	NA	12	12	32
BW (kg)	70	70	70	15	NA	NA	43	43	70
AT Noncancer (d)	9125	25550	25550	2190	NA	NA	4380	4380	11680
AT Cancer (d)	25550	25550	25550	25550	NA	NA	25550	25550	25550
CF-Chem (kg/mg)	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	NA	NA	1×10^{-6}	1×10^{-6}	1×10^{-6}
CF-Rad (g/mg)	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	NA	NA	1×10^{-3}	1×10^{-3}	1×10^{-3}
Dermal Contact with Soil/Sediment									
SA (cm^2)	5750	5750	5750	2000	NA	NA	4200	4200	5750
AF (mg/cm^2)	1.0	1.0	1.0	1.0	NA	NA	1.0	1.0	1.0
ABS (unitless)	CSV[d]	CSV	CSV	CSV	NA	NA	CSV	CSV	CSV
EF (d/yr)	250[c]	350	350	350	NA	NA	52	110	40
ED (yr)	25	70	70	6	NA	NA	12	12	32
BW (kg)	70	70	70	15	NA	NA	43	43	70
AT Noncancer (d)	9125	25550	25550	2190	NA	NA	4380	4380	11680
AT Cancer (d)	25550	25550	25550	25550	NA	NA	25550	25550	25550
CF-Chem (kg/mg)	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	NA	NA	1×10^{-6}	1×10^{-6}	1×10^{-6}

See footnotes at end of table.

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TABLE I.8-1
(Continued)

	RME Receptor								
		On-Property Resident Farm			Off-Property Resident Farm		Trespassing	Expanded Trespasser[b]	
								Childhood	Adulthood
Exposure Pathway	Groundskeeper	Adult(GMA)	Adult(P)	Child	Adult	Child	Child[b]	Years	Years
Soils/Vaults External Radiation Exposure									
ET Indoors (hr/d)	NA	18.3	18.3	22	NA	NA	NA	NA	NA
ET Outdoors(hr/d)	8	5.7	5.7	2	NA	NA	4	2	1
EF (d/yr)	250[c]	350	350	350	NA	NA	52	60	20
ED (yr)	25	70	70	6	NA	NA	12	12	32
SH Indoors (unitless)	NA	0.5	0.5	0.5	NA	NA	NA	NA	NA
SH Outdoors (unitless)	0	0	0	0	NA	NA	0	0	0
CF (yr/hr)	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}	NA	NA	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
Ingestion of Vegetables and Fruit									
IR (g/d)	NA	122	122	106	122	106	NA	NA	NA
FI (unitless)	NA	0.5	0.5	0.5	0.5	0.5	NA	NA	NA
EF (d/yr)	NA	350	350	350	350	350	NA	NA	NA
ED (yr)	NA	70	70	6	70	6	NA	NA	NA
BW (kg)	NA	70	70	15	70	15	NA	NA	NA
AT Noncancer (d)	NA	25550	25550	2190	25550	2190	NA	NA	NA
AT Cancer (d)	NA	25550	25550	25550	25550	25550	NA	NA	NA
CF (kg/g)	NA	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	NA	NA	NA
Ingestion of Meat									
IR (g/d)	NA	75	75	29	75	29	NA	NA	NA
FI (unitless)	NA	1	1	1	1	1	NA	NA	NA
EF (d/yr)	NA	350	350	350	350	350	NA	NA	NA
ED (yr)	NA	70	70	6	70	6	NA	NA	NA
BW (kg)	NA	70	70	15	70	15	NA	NA	NA
AT Noncancer (d)	NA	25550	25550	2190	25550	2190	NA	NA	NA

See footnotes at end of table.

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TABLE I.8-1
(Continued)

	RME Receptor								
		On-Property Resident Farm			Off-Property Resident Farm		Trespassing	Expanded Trespasser[b]	
								Childhood	Adulthood
Exposure Pathway	Groundskeeper	Adult(GMA)	Adult(P)	Child	Adult	Child	Child[b]	Years	Years
Ingestion of Meat (Continued)									
AT Cancer (d)	NA	25550	25550	25550	25550	25550	NA	NA	NA
CF (kg/g)	NA	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}	NA	NA	NA
Ingestion of Milk									
IR (l/d)	NA	0.3	0.3	0.68	0.3	0.68	NA	NA	NA
FI (unitless)	NA	1	1	1	1	1	NA	NA	NA
EF (d/yr)	NA	350	350	350	350	350	NA	NA	NA
ED (yr)	NA	70	70	6	70	6	NA	NA	NA
BW (kg)	NA	70	70	15	70	15	NA	NA	NA
AT Noncancer (d)	NA	25550	25550	2190	25550	2190	NA	NA	NA
AT Cancer (d)	NA	25550	25550	25550	25550	25550	NA	NA	NA

Acronyms used in this table:

ABS = Absorption factor
AF = Soil-to-skin adherence factor
AT = Averaging time
BW = Body weight
CF = Conversion factor
CSV = Chemical specific value
DR = Dose equivalent rate
ED = Exposure duration
EF = Exposure frequency
ET = Exposure time
FD = Fraction of day
FI = Fraction ingested from contaminated source
FY = Fraction of year
GMA = Great Miami Aquifer (ingestion of water)
IR = Average inhalation rate or average ingestion rate based on pathway
NA = Not applicable
P = Perched groundwater (ingestion of)
SA = Skin surface area available for contact
SH = Building shielding factor

[a]Except where qualified by other footnotes, the values in this table are from the OU2 RI Report (DOE 1994a).
[b]Justification and clarification for these scenarios is provided in the OU4 FS Report (DOE 1993h).
[c]This value is different from the OU2 RI baseline risk assessment due to the site-wide nature of the CRANE compared to the more limited area of OU2.
[d]The CSV values are presented in Table I.8-2.

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TABLE I.8-2

DERMAL SOIL ABSORPTION COEFFICIENTS USED IN EXPOSURE MODEL[a]

COC	Soil Absorption Coefficient (unitless)	COC	Soil Absorption Coefficient (unitless)
Inorganics			
Antimony	1.00×10^{-2}	Thorium	1.00×10^{-2}
Arsenic	1.00×10^{-3}	Uranium	1.00×10^{-3}
Barium	1.00×10^{-2}	Vanadium	1.00×10^{-3}
Beryllium	1.00×10^{-2}	Zinc	1.00×10^{-2}
Boron	1.00×10^{-2}	**Semivolatile Organics**	
Cadmium	1.00×10^{-2}	2-Methylnaphthalene	3.00×10^{-1}
Chromium	1.00×10^{-2}	Carbazole	3.00×10^{-1}
Cobalt	1.00×10^{-2}	Dioxins/Furans[b]	3.00×10^{-2}
Copper	1.00×10^{-3}	**Pesticide/PCBs**	
Cyanide	1.00×10^{-2}	Aroclor-1221[b]	6.00×10^{-2}
Lead	1.00×10^{-2}	Aroclor-1248[b]	6.00×10^{-2}
Manganese	1.00×10^{-2}	Aroclor-1254[b]	6.00×10^{-2}
Mercury	5.00×10^{-2}	Aroclor-1260[b]	6.00×10^{-2}
Molybdenum	1.00×10^{-2}	4,4-DDE	3.00×10^{-1}
Nickel	5.00×10^{-4}	Endrin	3.00×10^{-1}
Selenium	1.00×10^{-2}		
Silver	1.00×10^{-2}		
Thallium	1.00×10^{-2}		

[a]Except where qualified by other footnotes, the values in this table are from the OU2 RI Report (DOE 1994a).
[b]EPA 1992f.

TABLE I.8-3

SUMMARY OF COC INTAKES: CURRENT LAND USE SCENARIO

RME Receptor	Exposure Pathways	Minimum CDI (mg/kg/day) (pCi)	Minimum Compound	Maximum CDI (mg/kg/day) (pCi)	Maximum Compound	Attachment I.IV Table Reference
Trespassing Child	Inhalation of Particulates					
	Chemicals	3.9×10^{-17}	TCDD	8.4×10^{-7}	Manganese	1
	Radionuclides	1.6×10^{-2}	Pu-239	5.5×10^{3}	Rn-222	2
	Ingestion of Soil					
	Chemicals	4.9×10^{-16}	TCDD	8.1×10^{-5}	Manganese	3
	Radionuclides	2.0×10^{-1}	Pu-239	3.2×10^{2}	U-234	4
	Ingestion while Wading					
	Radionuclides	8.5×10^{-2}	U-236	9.8×10^{2}	Tc-99	5
	Dermal Contact with Soil					
	Chemicals	2.5×10^{-15}	TCDD	1.4×10^{-4}	Manganese	6
	External Radiation					
	Radionuclides	3.6×10^{-3}	Pu-239	5.9×10^{0}	U-234	7
Groundskeeper	Inhalation of Particulates					
	Chemicals	1.4×10^{-15}	TCDD	1.5×10^{-5}	Manganese	8
	Radionuclides	9.5×10^{-1}	Pu-239	3.3×10^{5}	Rn-222	9
	Ingestion of Soil					
	Chemicals	1.2×10^{-14}	TCDD	9.5×10^{-4}	Manganese	10
	Radionuclides	7.8×10^{0}	Pu-239	8.6×10^{3}	U-238	11
	Dermal Contact with Soil					
	Chemicals	2.1×10^{-14}	TCDD	5.5×10^{-4}	Manganese	12
	External Radiation					
	Radionuclides	7×10^{-2}	Pu-239	1.2×10^{2}	U-234	13
Off-Property Resident Farm Adult	Inhalation of Particulates					
	Chemicals	5.6×10^{-15}	TCDD	2.1×10^{-5}	Manganese	14
	Radionuclides	3.7×10^{0}	Pu-239	1.3×10^{6}	Rn-222	15
	Ingestion of Drinking Water					
	Chemicals	6.05×10^{-36}	Aroclor 1221	8.36×10^{9}	Antimony	16
	Radionuclides	3.8×10^{2}	Np-237	2.0×10^{7}	Tc-99	17

CDI = Chronic daily intake

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TABLE I.8-3
(Continued)

RME Receptor	Exposure Pathways	Minimum CDI (mg/kg/day) (pCi)	Minimum Compound	Maximum CDI (mg/kg/day) (pCi)	Maximum Compound	Attachment I.IV Table Reference
	Ingestion of Meat					
	Chemicals	1.4×10^{-17}	Cyanide	9.3×10^{-9}	Zinc	18
	Radionuclides	7.3×10^{-8}	Pu-239	1.7×10^{2}	U-234	19
	Ingestion of Dairy Products					
	Chemicals	1.8×10^{-17}	Cyanide	3.7×10^{-9}	Zinc	20
	Radionuclides	5.7×10^{-28}	Ru-106	2.5×10^{3}	U-234	21
	Ingestion of Vegetables					
	Chemicals	2.3×10^{-18}	TCDD	8.7×10^{-9}	Manganese	22
	Radionuclides	6.6×10^{-14}	Ru-106	6.8×10^{4}	U-234	23
Off-Property Resident Farm Child	Inhalation of Particulates					
	Chemicals	1.4×10^{-15}	TCDD	5.9×10^{-5}	Manganese	24
	Radionuclides	1.9×10^{-9}	Pu-239	6.7×10^{4}	Rn-222	25
	Ingestion of Drinking Water					
	Chemicals	1.2×10^{-36}	Ar-1221	2.0×10^{-8}	Antimony	26
	Radionuclides	1.6×10^{1}	Np-237	8.5×10^{5}	Tc-99	27
	Ingestion of Meat					
	Chemicals	2.5×10^{-17}	Cyanide	1.7×10^{-8}	Zinc	28
	Radionuclides	2.4×10^{-9}	Pu-239	5.6×10^{0}	U-234	29
	Ingestion of Dairy Products					
	Chemicals	1.9×10^{-16}	Cyanide	3.9×10^{-8}	Zinc	30
	Radionuclides	1.1×10^{-28}	Ru-106	4.8×10^{2}	U-234	31
	Ingestion of Vegetables					
	Chemicals	8.1×10^{-19}	TCDD	3.5×10^{-8}	Manganese	32
	Radionuclides	4.9×10^{-15}	Ru-106	5.0×10^{3}	U-234	33

CDI = Chronic daily intake

TABLE I.8-4

SUMMARY OF COC INTAKES: FUTURE LAND USE WITH FEDERAL OWNERSHIP

RME Receptor Pathways	Exposure Pathways		Minimum CDI (mg/kg/day) (pCi)	Compound	Maximum CDI (mg/kg/day) (pCi)	Compound	Attachment I.IV Table Reference
Expanded Trespasser	Inhalation of Particulates						
		Chemicals	5.7×10^{-17}	TCDD	9.9×10^{-7}	Manganese	34
		Radionuclides	2.5×10^{-2}	Pu-239	8.7×10^{3}	Rn-222	35
	Ingestion of Soil						
		Chemicals	8.3×10^{-16}	TCDD	1.0×10^{-4}	Manganese	36
		Radionuclides	4.1×10^{-1}	Pu-239	6.7×10^{2}	U-234	37
	Ingestion while Wading						
		Radionuclides	4.8×10^{0}	U-236	1.9×10^{4}	Tc-99	38
	Dermal Contact with Soil						
		Chemical	9.6×10^{-15}	TCDD	3.8×10^{-4}	Manganese	39
	External Radiation						
		Radionuclides	2.7×10^{-3}	Pu-239	4.5×10^{0}	U-234	40
Trespassing Child	Inhalation of Particulates						
		Chemicals	3.9×10^{-17}	TCDD	8.4×10^{-7}	Manganese	41
		Radionuclides	1.6×10^{-2}	Pu-239	5.5×10^{3}	Rn-222	42
	Ingestion of Soil						
		Chemical	4.9×10^{-16}	TCDD	8.1×10^{-5}	Manganese	43
		Radionuclides	2.0×10^{-1}	Pu-239	3.2×10^{2}	U-234	44
	Ingestion while Wading						
		Radionuclides	6.5×10^{-1}	U-236	2.6×10^{3}	Tc-99	45
	Dermal Contact with Soil						
		Chemical	2.5×10^{-15}	TCDD	1.4×10^{-4}	Manganese	46
	External Radiation						
		Radionuclides	3.6×10^{-3}	Pu-239	5.9×10^{0}	U-234	47

CDI = Chronic daily intake

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TABLE I.8-4
(Continued)

RME Receptor Pathways	Exposure Pathways		Minimum CDI (mg/kg/day) (pCi)	Minimum Compound	Maximum CDI (mg/kg/day) (pCi)	Maximum Compound	Attachment I.IV Table Reference
Off-Property Resident Farm Adult	Inhalation of Particulates						
		Chemicals	5.6×10^{-15}	TCDD	2.1×10^{-5}	Manganese	48
		Radionuclides	3.7×10^{0}	Pu-239	1.3×10^{6}	Rn-222	49
	Ingestion of Drinking Water						
		Chemicals	4.7×10^{-26}	Cadmium	1.9×10^{-9}	Antimony	50
		Radionuclides	3.9×10^{3}	Np-237	6.0×10^{7}	Tc-99	51
	Ingestion of Meat						
		Chemicals	5.4×10^{-13}	4.4-DDE	9.3×10^{-9}	Zinc	52
		Radionuclides	7.3×10^{-8}	Pu-239	4.8×10^{2}	U-234	53
	Ingestion of Dairy Products						
		Chemicals	2.3×10^{-15}	Beryllium	3.7×10^{-9}	Zinc	54
		Radionuclides	5.7×10^{-28}	Ru-106	6.9×10^{3}	U-234	55
	Ingestion of Vegetables						
		Chemicals	2.3×10^{-18}	TCDD	8.7×10^{-9}	Manganese	56
		Radionuclides	6.6×10^{-14}	Ru-106	1.9×10^{5}	U-234	57
Off-Property Resident Farm Child	Inhalation of Particulates						
		Chemicals	1.4×10^{-15}	TCDD	5.9×10^{-5}	Manganese	58
		Radionuclides	1.9×10^{-1}	Pu-239	6.7×10^{4}	Rn-222	59
	Ingestion of Drinking Water						
		Chemicals	5.6×10^{-30}	Ar-1221	4.41×10^{-9}	Antimony	60
		Radionuclides	1.7×10^{2}	Np-237	2.6×10^{6}	Tc-99	61
	Ingestion of Meat						
		Chemicals	8.4×10^{-14}	4.4-DDE	1.7×10^{-8}	Zinc	62
		Radionuclides	2.4×10^{-9}	Pu-239	1.6×10^{1}	U-234	63
	Ingestion of Dairy Products						
		Chemicals	2.1×10^{-15}	Beryllium	3.9×10^{-8}	Zinc	64
		Radionuclides	1.1×10^{-28}	Ru-106	1.3×10^{3}	U-234	65
	Ingestion of Vegetables						
		Chemicals	8.1×10^{-19}	TCDD	3.5×10^{-8}	Manganese	66
		Radionuclides	4.9×10^{-15}	Ru-106	1.4×10^{4}	U-234	67

CDI = Chronic daily intake

TABLE I.8-5

SUMMARY OF COC INTAKES: FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

RME Receptor Pathways	Exposure Pathways		Minimum CDI (mg/kg/day) (pCi)	Minimum Compound	Maximum CDI (mg/kg/day) (pCi)	Maximum Compound	Attachment I.IV Table Reference
On-Property Resident Farm Adult (Great Miami Aquifer Groundwater)	Inhalation of Particulates						
		Chemicals	3.9×10^{-14}	TCDD	4.1×10^{-5}	Manganese	68
		Radionuclides	2.2×10^{1}	Ru-106	3.2×10^{6}	Rn-222	69
	Ingestion of Soil						
		Chemicals	1.3×10^{-11}	TCDD	5.3×10^{-3}	Manganese	70
		Radionuclides	1.8×10^{3}	Th-228	3.3×10^{6}	U-234	71
	Ingestion of Drinking Water						
		Chemicals	6.3×10^{-26}	Ar-1221	3.4×10^{-5}	Antimony	72
		Radionuclides	2.8×10^{4}	Np-237	2.6×10^{8}	Tc-99	73
	Dermal Contact with Soil						
		Chemicals	1.3×10^{-11}	TCDD	1.7×10^{-3}	Manganese	74
	External Radiation						
		Radionuclides	1.6×10^{1}	Th-228	3.1×10^{4}	U-234	75
	Ingestion of Meat						
		Chemicals	6.1×10^{-7}	4.4-DDE	5.0×10^{-1}	Zinc	76
		Radionuclides	6.0×10^{-3}	Pu-239	9.7×10^{4}	Cs-137	77
	Ingestion of Dairy Products						
		Chemicals	2.8×10^{-9}	Beryllium	2.0×10^{-1}	Zinc	78
		Radionuclides	1.3×10^{-21}	Ru-106	1.4×10^{5}	Cs-137	79
	Ingestion of Vegetables						
		Chemicals	2.3×10^{-18}	TCDD	8.0×10^{-2}	Boron	80
		Radionuclides	6.6×10^{-8}	Ru-106	7.9×10^{5}	U-234	81

CDI = Chronic daily intake

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TABLE I.8-5
(Continued)

RME Receptor Pathways	Exposure Pathways		Minimum CDI (mg/kg/day) (pCi)	Minimum Compound	Maximum CDI (mg/kg/day) (pCi)	Maximum Compound	Attachment I.IV Table Reference
On-Property Resident Farm Adult (Perched Groundwater)	Inhalation of Particulates						
		Chemicals	3.9×10^{-14}	TCDD	1.6×10^{-5}	Boron	82
		Radionuclides	2.2×10^{1}	Ru-106	3.2×10^{6}	Rn-222	83
	Ingestion of Soil						
		Chemicals	1.4×10^{-11}	TCDD	5.3×10^{-3}	Manganese	84
		Radionuclides	1.8×10^{3}	Th-228	3.3×10^{6}	U-234	85
	Ingestion of Drinking Water						
		Chemicals	3.3×10^{-4}	Ar-1221		Not Applicable	86
		Radionuclides	1.7×10^{5}	U-236	8.8×10^{8}	Tc-99	87
	Dermal Contact with Soil						
		Chemicals	1.3×10^{-11}	TCDD	1.7×10^{-3}	Manganese	88
	External Radiation						
		Radionuclides	1.6×10^{1}	Th-228	3.1×10^{4}	U-234	89
	Ingestion of Meat						
		Chemicals	6.1×10^{-7}	4.4-DDE	5.0×10^{-1}	Zinc	90
		Radionuclides	6.0×10^{-3}	Pu-239	9.7×10^{4}	Cs-137	91
	Ingestion of Dairy Products						
		Chemicals	2.8×10^{-9}	Beryllium	2.0×10^{-4}	Zinc	92
		Radionuclides	1.3×10^{-21}	Ru-106	2.2×10^{5}	U-238	93
	Ingestion of Vegetables						
		Chemicals	2.3×10^{-18}	TCDD	8.0×10^{-2}	Boron	94
		Radionuclides	6.6×10^{-8}	Ru-106	4.5×10^{6}	U-238	95
On-Property Resident Farm Child	Inhalation of Particulates						
		Chemicals	9.4×10^{-15}	TCDD	1.2×10^{-4}	Manganese	96
		Radionuclides	1.1×10^{0}	Ru-106	1.6×10^{5}	Rn-222	97
	Ingestion of Soil						
		Chemicals	6.1×10^{-12}	TCDD	2.7×10^{-2}	Manganese	98
		Radionuclides	1.7×10^{2}	Th-228	1.2×10^{6}	U-234	99

CDI = Chronic daily intake

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TABLE I.8-5
(Continued)

RME Receptor Pathways	Exposure Pathways		Minimum CDI (mg/kg/day) (pCi)	Minimum Compound	Maximum CDI (mg/kg/day) (pCi)	Maximum Compound	Attachment I.IV Table Reference
	Ingestion of Drinking Water						
		Chemicals	1.3×10^{-26}	Ar-1221	7.9×10^{-5}	Antimony	100
		Radionuclides	1.2×10^{3}	Np-237	1.1×10^{7}	Tc-99	101
	Dermal Contact with Soil						
		Chemicals	1.8×10^{-12}	TCDD	2.7×10^{-3}	Manganese	102
	External Radiation						
		Radionuclides	1.2×10^{0}	Th-228	8.9×10^{3}	U-234	103
	Ingestion of Meat						
		Chemicals	9.4×10^{-8}	4.4-DDE	3.3×10^{-2}	Boron	104
		Radionuclides	2.0×10^{-4}	Pu-239	3.2×10^{3}	Cs-137	105
	Ingestion of Dairy Products						
		Chemicals	2.5×10^{-8}	Beryllium	2.1×10^{0}	Zinc	106
		Radionuclides	2.6×10^{-22}	Ru-106	2.6×10^{4}	Cs-137	107
	Ingestion of Vegetables						
		Chemicals	8.1×10^{-19}	TCDD	3.2×10^{-1}	Boron	108
		Radionuclides	4.9×10^{-9}	Ru-106	5.9×10^{4}	U-234	109
Off-Property Resident Farm Adult	Inhalation of Particulates						
		Chemicals	5.6×10^{-15}	TCDD	2.1×10^{-5}	Manganese	110
		Radionuclides	3.7×10^{0}	Pu-239	1.3×10^{6}	Rn-222	111
	Ingestion of Drinking Water						
		Chemicals	2.8×10^{-29}	Ar-1221	1.9×10^{-9}	Antimony	112
		Radionuclides	3.9×10^{3}	Np-237	6.0×10^{7}	Tc-99	113
	Ingestion of Meat						
		Chemicals	5.4×10^{-13}	4.4-DDE	9.3×10^{-9}	Zinc	114
		Radionuclides	7.3×10^{-8}	Pu-239	4.8×10^{2}	U-234	115
	Ingestion of Dairy Products						
		Chemicals	2.3×10^{-15}	Beryllium	3.7×10^{-9}	Zinc	116
		Radionuclides	5.7×10^{-28}	Ru-106	6.9×10^{3}	U-234	117
	Ingestion of Vegetables						
		Chemicals	2.3×10^{-18}	TCDD	8.7×10^{-9}	Manganese	118
		Radionuclides	6.6×10^{-14}	Ru-106	1.9×10^{5}	U-234	119

CDI = Chronic daily intake

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TABLE I.8-5
(Continued)

RME Receptor Pathways	Exposure Pathways	Minimum CDI (mg/kg/day) (pCi)	Minimum Compound	Maximum CDI (mg/kg/day) (pCi)	Maximum Compound	Attachment I.IV Table Reference
Off-Property Resident Farm Child	Inhalation of Particulates					
	Chemicals	1.4×10^{-15}	TCDD	5.9×10^{-5}	Manganese	120
	Radionuclides	1.9×10^{-1}	Pu-239	6.7×10^{4}	Rn-222	121
	Ingestion of Drinking Water					
	Chemicals	5.6×10^{-30}	Ar-1221	4.4×10^{-9}	Antimony	122
	Radionuclides	1.7×10^{2}	Np-237	2.6×10^{6}	Tc-99	123
	Ingestion of Meat					
	Chemicals	9.9×10^{-14}	Beryllium	1.7×10^{-8}	Zinc	124
	Radionuclides	2.4×10^{-9}	Pu-239	1.6×10^{1}	U-234	125
	Ingestion of Dairy Products					
	Chemicals	2.1×10^{-15}	Beryllium	3.9×10^{-8}	Zinc	126
	Radionuclides	1.1×10^{-28}	Ru-106	1.3×10^{3}	U-234	127
	Ingestion of Vegetables					
	Chemicals	8.1×10^{-19}	TCDD	3.5×10^{-8}	Manganese	128
	Radionuclides	4.9×10^{-15}	Ru-106	1.4×10^{4}	U-234	129

CDI = Chronic daily intake

I.9.0 RISK CHARACTERIZATION

Risk characterization is the final step in the CRARE process, combining the information developed in the toxicity assessment (Section I.7.0) and the exposure assessment (Section I.8.0). The potential of a COC to cause carcinogenic effects is presented as the incremental lifetime cancer risk (ILCR). Potential noncarcinogenic effects are presented as hazard quotients (HQs) or hazard indices (HIs), as defined in Section I.9.1.2.

Upper-bound risk estimates for receptors are presented either qualitatively or quantitatively, depending on the quality of the input parameters. Section I.9.1 describes the methodology employed to characterize health risks. Short-term risks associated with remediation are summarized in Section I.9.2. The residual human health risks, by exposure pathway, appear in Section I.9.3. Uncertainties associated with the risk characterization are examined in Section I.10.0.

I.9.1 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 1991f)
- *Health Effects Assessment Summary Tables* (EPA 1993c)
- *Exposure Factors Handbook* (EPA 1989e)
- *Integrated Risk Information System* (EPA 1994a)

I.9.1.1 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.

I.9.1.1.1 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):

$$\text{Risk} = (\text{CDI})(\text{SF}) \qquad (1)$$

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 $(\text{mg/kg/day})^{-1}$.

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:

$$\text{Risk}_p = \text{Risk}\ (\text{chem}_1) + \text{Risk}\ (\text{chem}_2) + \ldots\ \text{Risk}\ (\text{chem}_i) \qquad (2)$$

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}. A cancer risk of 10^{-6} served as the point of departure for CERCLA remediation goals (Federal Register 1990).

I.9.1.1.2 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 reference dose (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):

$$HQ = I/RfD \quad (3)$$

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 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:

$$HI = I_i/RfD_1 + I_2/RfD_2 + ...I_i/RfD_i \quad (4)$$

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 organs, such as hepatic, renal, respiratory, cardiovascular, and dermal/ocular problems (EPA 1989d).

As requested by EPA, and in compliance with EPA guidance in RAGS, an analysis of target organ/mechanism of action was performed for any receptor whose HI is greater than 1.

I.9.1.2 Radiological Exposures

The procedures for estimating the total lifetime excess cancer risks due to continuous, lifetime exposure (i.e., a 70-year average life span) to radionuclides are described in this section.

I.9.1.2.1 Risk Characterization Methodology for Internal Exposures

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

$$\text{Risk} = (I)(SF) \qquad (5)$$

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.

I.9.1.2.2 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:

$$\text{Risk} = (SF)[(C_s)(EF)(ED)(ET)(1 - SH)] \qquad (6)$$

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 (1991a),
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 products in

the overall risk calculation. Progeny product concentrations were determined using Rad Decay, a radionuclide library and decay software program. Parent isotopes were decayed over a period of interest to predict future levels.

I.9.2 SHORT-TERM RISK EVALUATION FOR OPERABLE UNITS 1, 2, AND 4

The Operable Unit 1, 2, and 4 FS risk evaluations considered short-term health risks during remedial activities from construction, transportation, chemical exposure, and radionuclide exposure. The results are summarized below. The Operable Unit 3 and 5 short-term risks are not available as their FSs are not complete, but the information will be included in future CRAREs when it becomes available. Note that this CRARE is based on updated PRAs for Operable Units 1, 2, and 4 and on the LRAs from the SWCR for Operable Units 3 and 5.

I.9.2.1 Operable Unit 1 Short-Term Risks

The short-term risks associated with Operable Unit 1 off-site disposal remedial activities are from exposures incurred over the duration of the remediation. The risks evaluated are the ILCR associated with exposure to chemical carcinogens and ionizing radiation, toxic effects associated with noncarcinogenic chemicals, and direct physical injuries associated with operating machinery. The risk assessment estimated the exposure risks for three groups of individuals: remediation workers, nonremediation workers, and the general public. Remediation workers are at risk through their direct involvement in a specific component of a remedial alternative. Nonremediation workers (all other workers within the FEMP) are at risk from the airborne transport of contaminants from Operable Unit 1 to their workplace. The general public living adjacent to the FEMP is at risk from the off-site atmospheric transport of airborne contaminants from the operable unit. The general public living adjacent to the transport route for Operable Unit 1 waste materials is at risk from external radiation associated with transport containers and the accidental release of waste material during transportation.

Operable Unit 1 remedial activities will deliver an estimated dose to remediation workers of 61 millirem over the course of the remediation. The radiological and chemical ILCR to nonremediation workers is 5.2×10^{-5}, and their HI is 6.3×10^{-8}. The radiological and chemical ILCR to off-site individuals is 2.9×10^{-6}, and their HI is 3.5×10^{-9}. The collective radioactive dose equivalent estimates for truck drivers and train crew are 4×10^{-4} and 4.5×10^{-1} person-rem, respectively, for the total shipment of material. For the total shipment, the off-site individual's

maximum ILCR from radiation exposure is 4.6×10^{-6}. The ILCR from an accident during transport would be 4.6×10^{-5} for a train accident and 1.2×10^{-8} for a truck accident (DOE 1993g).

I.9.2.2 Operable Unit 2 Short-Term Risks

The short-term risks associated with Operable Unit 2 remediation were estimated for a trespassing youth, a nonremediation worker, and an off-property farmer exposed to surface soil during remedial activities at the South Field, Active Flyash Pile, Inactive Flyash Pile, Solid Waste Landfill, and Lime Sludge Ponds.

Both noncarcinogenic and carcinogenic risks were summed across all applicable soil pathways for these receptors. Carcinogenic risk did not deviate from the point of departure, and a hazard index of 1.0 was not exceeded for any proposed remedial alternative. ILCR did not exceed 2.6×10^{-6} and HI did not exceed 1.6×10^{-3} for the nonremediation worker. For the trespassing youth, ILCR did not exceed 2.4×10^{-6} and HI did not exceed 3.6×10^{-3}. For the off-property farmer, ILCR did not exceed 1.0×10^{-6} (DOE 1994b).

I.9.2.3 Operable Unit 4 Short-Term Risks

The receptors, exposure media, and exposure pathways considered in the Operable Unit 4 FS risk evaluation consist of a nonremediation worker exposed to radon and contaminated soil particulates in the air (comparable to the CRARE groundskeeper), a trespassing child exposed to contaminated soil particulates in the air and direct contact with surface soils, and an off-property resident farm adult exposed to radon and contaminated soil particulates in the air. Groundwater was not considered a complete pathway for short-term risks. Risks due to accidents were considered for remediation workers, workers involved in the transport of wastes or soils by truck and train, and the general public. The Operable Unit 4 FS report contains a complete description of these risks for each considered alternative of Operable Unit 4.

The greatest health risk for the nonremediation worker is exposure to total suspended particulate from the berm and surface soils. The radiological ILCR is 3.3×10^{-7} and the chemical ILCR is 2.5×10^{-10}. The total ILCR is lower than the departure point of 1×10^{-6}. Since the risk to the remediation worker is less than the departure point, the risk to the off-property public would also be insignificant because of the additional dilution of dust in the air for the off-property receptor. The HI is less than 10^{-4}, which is below the benchmark of 1.0 and would not present a concern to

the public. The radon risk to the nonremediation worker while the treatment facility is operating is 5.8×10^{-7} (DOE 1993h).

If a trespassing child comes into contact with operable unit soils, the ILCR would be 3.8×10^{-7} for radiological ILCR and 2.5×10^{-6} for chemical risk. While the cancer risk is within the target risk range, it is unlikely that a child would be present during remedial activities on a controlled-access site and consequently would not be exposed to the operable unit materials. Similarly, the HI for noncarcinogenic risks is 0.14, below the target of 1.0 (DOE 1993h).

Engineering controls will be used during remedial activities to limit radon release to as low as reasonably achievable (ALARA) levels. The target level at the fenceline is 4 pCi/l (indoor air quality). Engineering evaluations have estimated that the on-property radon concentration would be 0.12 pCi/l during treatment plant operation, and 0.002 pCi/l at the fence line. For three years of operation, this represents risk estimates of 5.8×10^{-7} and 3.3×10^{-7}, respectively (DOE 1993h).

In summary, it appears that Operable Unit 4 remedial activities would cause no short-term adverse risks to off-property receptors (DOE 1993h).

I.9.3 RESIDUAL HUMAN HEALTH RISKS

This section presents the ILCR and HI estimates for all receptors, by pathway, under each of the three land use scenarios. Table I.9-1 summarizes this information. Complete calculation sheets of the risk values and subsequent target organ analysis can be found in Attachment I.IV. The tables in Sections I.9.3.1 through I.9.3.3 present the risk values in a uniform format: the top portion presents the HI values derived from each exposure pathway applicable to the receptor; the bottom portion presents the ILCR values for the receptor by applicable pathways. The ILCR values resulting from exposures to pathways that include both radionuclides and carcinogenic COCs are presented separately to present the magnitude of risk contributed by each. While reviewing these risk values, please note that a receptor can be exposed to different COCs via different exposure pathways for each scenario. Major contributors to this phenomenon include changes in site accessibility and physical conditions, and COC migration in the environment (see Section I.5.0 for a detailed discussion).

TABLE I.9-1

SUMMARY OF ILCR AND HI FOR ALL SCENARIOS, ALL PATHWAYS

Current Land Use

RME Receptor	ILCR	HI
Groundskeeper	1.4×10^{-4}	1.1×10^{0}
Trespassing Child	1.1×10^{-5}	1.2×10^{-1}
Off-Property Farm Residents		
Adult	1.2×10^{-4}	1.1×10^{0}
Child	9.0×10^{-6}	3.0×10^{0}

Future Land Use With Federal Ownership

RME Receptor	ILCR	HI
Expanded Trespasser	3.3×10^{-5}	2.4×10^{-1}
Trespassing Child	1.1×10^{-5}	1.2×10^{-1}
Off-Property Farm Residents		
Adult	2.0×10^{-4}	1.1×10^{0}
Child	1.3×10^{-5}	3.0×10^{0}

Future Land Use Without Federal Ownership

RME Receptor	ILCR	HI
On-Property Farm Residents		
Adult (ingests perched groundwater)	1.2×10^{-2}	2.2×10^{1}
Adult (ingests GMA water)	5.0×10^{-3}	2.2×10^{1}
Child	8.2×10^{-4}	9.4×10^{1}
Off-Property Farm Residents		
Adult	2.0×10^{-4}	1.1×10^{0}
Child	1.3×10^{-5}	3.0×10^{0}

GMA = Great Miami Aquifer

I.9.3.1 Risks Under Current Land Use Scenario

Groundskeeper

Table I.9-2 presents the exposure pathway contribution to the total HI and ILCR for the groundskeeper receptor in the Current Land Use scenario. The total HI is seen to be 1.1, with the major pathway being the inhalation of particulates (7.6×10^{-1}). The principal contributors are cobalt (6.07×10^{-1}) and manganese (1.36×10^{-1}), and the target organs receiving the principal impact are the liver (6.07×10^{-1}) and central nervous system (1.36×10^{-1}), respectively.

The ILCR for this receptor is an estimated 1.4×10^{-4}, with the major contributors being external radiation (4.8×10^{-5}) and dermal contact with soil and sediment (6.5×10^{-5}). The principal contributors to the external radiation cancer risk are Ra-226 (1.3×10^{-5}), Ra-228 (1.1×10^{-5}) and Th-228 (1.3×10^{-5}).

TABLE I.9-2

SUMMARY OF POTENTIAL HEALTH EFFECTS: GROUNDSKEEPER (CURRENT LAND USE)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	7.6×10^{-1}
Incidental Ingestion of Soil/Sediment (Chemicals)	6.1×10^{-2}
Dermal Contact with Soil/Sediment (Chemicals)	2.7×10^{-1}
RME Individual HI:	1.1×10^{0}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	4.4×10^{-6}
Inhalation of Particulates (Radionuclides)	1.5×10^{-6}
Incidental Ingestion of Soil/Sediment (Chemicals)	4.3×10^{-6}
Incidental Ingestion of Soil/Sediment (Radionuclides)	1.1×10^{-6}
Dermal Contact with Soil/Sediment (Chemicals)	6.5×10^{-5}
External Radiation Exposure	4.8×10^{-5}
RME Individual ILCR:	1.4×10^{-4}

Trespassing Child

HI and ILCR values associated with the trespassing child are presented in Table I.9-3. The predicted total HI (1.2×10^{-1}) is below the level of concern, and the ILCR (1.1×10^{-5}) is within the target risk range. The major contributors are the same as those for the groundskeeper: external radiation, inhalation of particulates, and dermal contact with soils.

TABLE I.9-3

SUMMARY OF POTENTIAL HEALTH EFFECTS: TRESPASSING CHILD (CURRENT LAND USE)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	4.3×10^{-2}
Incidental Ingestion of Soil/Sediment (Chemicals)	5.2×10^{-3}
Dermal Contact with Soil/Sediment (Chemicals)	6.8×10^{-2}
RME Individual HI:	1.2×10^{-1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	1.2×10^{-7}
Inhalation of Particulates (Radionuclides)	2.4×10^{-7}
Incidental Ingestion while Wading (Radionuclides)	1.5×10^{-9}
Incidental Ingestion of Soil/Sediment (Chemicals)	1.8×10^{-7}
Incidental Ingestion of Soil/Sediment (Radionuclides)	2.8×10^{-8}
Dermal Contact with Soil/Sediment (Chemicals)	7.8×10^{-6}
External Radiation Exposure	2.5×10^{-6}
RME Individual ILCR:	1.1×10^{-5}

Off-Property Resident Farm Adult

The risk results for this receptor are presented in Table I.9-4. Inhalation of particulates is seen to present an HI of 1.1, with the principal contributors being cobalt (8.50×10^{-1}) and manganese (1.91×10^{-1}). The target organs significantly impacted by these contaminants are the liver (8.50×10^{-1}) and the central nervous system (1.91×10^{-1}), respectively.

The estimated total ILCR (1.2×10^{-4}) exceeds the target risk range (10^{-4} to 10^{-6}). The principal contributors are the risks due to inhalation of chemical and radionuclide particulates (7.4×10^{-5}) and the ingestion of drinking water (4.1×10^{-5}).

TABLE I.9-4

SUMMARY OF POTENTIAL HEALTH EFFECTS:
OFF-PROPERTY RESIDENT FARM ADULT (CURRENT LAND USE)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	1.1×10^{0}
Ingestion of Drinking Water (Chemicals)	2.1×10^{-5}
Ingestion of Meat (Chemicals)	7.1×10^{-7}
Ingestion of Dairy Products (Chemicals)	7.7×10^{-7}
Ingestion of Vegetables and Fruit (Chemicals)	2.9×10^{-6}
RME Individual HI:	1.1×10^{0}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemical)	1.7×10^{-5}
Inhalation of Particulates (Radionuclides)	5.7×10^{-5}
Ingestion of Drinking Water (Chemicals)	4.7×10^{-35}
Ingestion of Drinking Water (Radionuclides)	4.1×10^{-5}
Ingestion of Meat (Chemicals)	1.5×10^{-10}
Ingestion of Meat (Radionuclides)	5.7×10^{-9}
Ingestion of Dairy Products (Chemicals)	1.6×10^{-10}
Ingestion of Dairy Products (Radionuclides)	8.2×10^{-8}
Ingestion of Vegetables and Fruit (Chemicals)	1.9×10^{-10}
Ingestion of Vegetables and Fruit (Radionuclides)	2.3×10^{-6}
RME Individual ILCR:	1.2×10^{-4}

Off-Property Resident Farm Child

The total HI for this receptor (3.0) is due almost totally to inhalation of particulates and is above the benchmark (Table I.9-5). Principal contributors are cobalt (2.38) and manganese (5.35×10^{-1}). The target organ impacted by these contributors are the liver (2.38×10^{0}) and the central nervous system (5.35×10^{-1}), respectively.

A total ILCR of 9.0×10^{-6} is predicted for this receptor, with inhalation of particulates contributing more than 75 percent (Table I.9-5). The total ILCR is within the target risk range, with the principal contributors being the same as those for the off-property resident farm adult (inhalation of chemical and radionuclide particulates, and ingestion of drinking water).

TABLE I.9-5

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM CHILD (CURRENT LAND USE)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	3.0×10^{0}
Ingestion of Drinking Water (Chemicals)	4.9×10^{-5}
Ingestion of Meat (Chemicals)	1.3×10^{-6}
Ingestion of Dairy Products (Chemicals)	8.2×10^{-6}
Ingestion of Vegetables and Fruit (Chemicals)	1.2×10^{-5}
RME Individual HI:	3.0×10^{0}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	4.1×10^{-6}
Inhalation of Particulates (Radionuclides)	2.9×10^{-6}
Ingestion of Drinking Water (Chemicals)	9.3×10^{-36}
Ingestion of Drinking Water (Radionuclides)	1.8×10^{-6}
Ingestion of Meat (Chemicals)	2.3×10^{-11}
Ingestion of Meat (Radionuclides)	1.9×10^{-10}
Ingestion of Dairy Products (Chemicals)	1.5×10^{-10}
Ingestion of Dairy Products (Radionuclides)	1.6×10^{-8}
Ingestion of Vegetables and Fruit (Chemicals)	6.5×10^{-11}
Ingestion of Vegetables and Fruit (Radionuclides)	1.7×10^{-7}
RME Individual ILCR:	9.0×10^{-6}

I.9.3.2 Risks Under Future Land Use With Federal Ownership Scenario

Expanded Trespasser

The total HI for this receptor is 2.4×10^{-1}, below the 1.0 benchmark. A total ILCR of 3.3×10^{-5} is predicted, with external radiation exposure (1.9×10^{-6}) and dermal contact with soil and sediment while on-site (3.0×10^{-5}) contributing 97 percent of the ILCR. This falls within the 10^{-4} to 10^{-6} target range (Table I.9-6).

TABLE I.9-6

SUMMARY OF POTENTIAL HEALTH EFFECTS: EXPANDED TRESPASSER (FUTURE LAND USE WITH FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	5.0×10^{-2}
Incidental Ingestion of Soil/Sediment (Chemicals)	6.7×10^{-3}
Dermal Contact with Soil/Sediment (Chemicals)	1.9×10^{-1}
RME Individual HI:	2.4×10^{-1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	1.6×10^{-7}
Inhalation of Particulates (Radionuclides)	3.8×10^{-7}
Incidental Ingestion while Wading (Radionuclides)	4.0×10^{-8}
Incidental Ingestion of Soil/Sediment (Chemicals)	3.0×10^{-7}
Incidental Ingestion of Soil/Sediment (Radionuclides)	5.8×10^{-8}
Dermal Contact with Soil/Sediment (Chemicals)	3.0×10^{-5}
External Radiation Exposure	1.9×10^{-6}
RME Individual ILCR:	3.3×10^{-5}

Trespassing Child

HI and ILCR values associated with the trespassing child are presented in Table I.9-7. The predicted HI (1.2×10^{-1}) is below the level of concern, and the total ILCR (1.1×10^{-5}) is within the target risk range. The major contributors are the same as those for the trespassing child under the Current Land Use scenario: external radiation, inhalation of particulates, and dermal contact with soils.

TABLE I.9-7

SUMMARY OF POTENTIAL HEALTH EFFECTS: TRESPASSING CHILD (FUTURE LAND USE WITH FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	4.3×10^{-2}
Incidental Ingestion of Soil/Sediment (Chemicals)	5.2×10^{-3}
Dermal Contact with Soil/Sediment (Chemicals)	6.8×10^{-2}
RME Individual HI:	1.2×10^{-1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	1.2×10^{-7}
Inhalation of Particulates (Radionuclides)	2.4×10^{-7}
Incidental Ingestion while Wading (Radionuclides)	5.3×10^{-9}
Incidental Ingestion of Soil/Sediment (Chemicals)	1.8×10^{-7}
Incidental Ingestion of Soil/Sediment (Radionuclides)	2.8×10^{-8}
Dermal Contact with Soil/Sediment (Chemicals)	7.8×10^{-6}
External Radiation Exposure	2.5×10^{-6}
RME Individual ILCR:	1.1×10^{-5}

Off-Property Resident Farm Adult

The total HI for this receptor is 1.1 (Table I.9-8) and is driven by the inhalation of cobalt (8.50×10^{-1}) and manganese (1.91×10^{-1}). The principal target organs impacted by these contributors are the liver (8.50×10^{-1}) and the central nervous system (1.91×10^{-1}), respectively.

The ILCRs for chemical and radioactive COCs are presented in Table I.9-8, with the total for all pathways being greater than 10^{-4}. A total ILCR of 2.0×10^{-4} is predicted for this receptor, with the principal contributors being ingestion of radionuclides in drinking water.

TABLE I.9-8

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM ADULT (FUTURE LAND USE WITH FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	1.1×10^{0}
Ingestion of Drinking Water (Chemicals)	4.7×10^{-6}
Ingestion of Meat (Chemicals)	6.8×10^{-7}
Ingestion of Dairy Products (Chemicals)	7.6×10^{-7}
Ingestion of Vegetables and Fruit (Chemicals)	2.9×10^{-6}
RME Individual HI:	1.1×10^{0}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	1.7×10^{-5}
Inhalation of Particulates (Radionuclides)	5.7×10^{-5}
Ingestion of Drinking Water (Chemicals)	2.2×10^{-28}
Ingestion of Drinking Water (Radionuclides)	1.2×10^{-4}
Ingestion of Meat (Chemicals)	1.5×10^{-10}
Ingestion of Meat (Radionuclides)	1.6×10^{-8}
Ingestion of Dairy Products (Chemicals)	1.6×10^{-10}
Ingestion of Dairy Products (Radionuclides)	2.3×10^{-7}
Ingestion of Vegetables and Fruit (Chemicals)	1.9×10^{-10}
Ingestion of Vegetables and Fruit (Radionuclides)	6.4×10^{-6}
RME Individual ILCR:	2.0×10^{-4}

Off-Property Resident Farm Child

For this receptor, the total HI of 3.0 (Table I.9-9) is due to inhalation of particulates from cobalt (2.38) and manganese (5.35×10^{-1}). The effects of these contaminants are localized in the liver (2.38×10^{0}) and central nervous system (5.35×10^{-1}), respectively. A total ILCR of 1.3×10^{-5} is predicted, with inhalation of particulates and the ingestion of radionuclides in drinking water being the major contributors (Table I.9-9). The total ILCR is within the acceptable range.

TABLE I.9-9

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM CHILD (FUTURE LAND USE WITH FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	3.0×10^{0}
Ingestion of Drinking Water (Chemicals)	1.1×10^{-5}
Ingestion of Meat (Chemicals)	1.2×10^{-6}
Ingestion of Dairy Products (Chemicals)	8.0×10^{-6}
Ingestion of Vegetables and Fruit (Chemicals)	1.2×10^{-5}
RME Individual HI:	3.0×10^{0}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	4.1×10^{-6}
Inhalation of Particulates (Radionuclides)	2.9×10^{-6}
Ingestion of Drinking Water (Chemicals)	4.3×10^{-29}
Ingestion of Drinking Water (Radionuclides)	5.2×10^{-6}
Ingestion of Meat (Chemicals)	2.3×10^{-11}
Ingestion of Meat (Radionuclides)	5.4×10^{-10}
Ingestion of Dairy Products (Chemicals)	1.5×10^{-10}
Ingestion of Dairy Products (Radionuclides)	4.5×10^{-8}
Ingestion of Vegetables and Fruit (Chemicals)	6.5×10^{-11}
Ingestion of Vegetables and Fruit (Radionuclides)	4.8×10^{-7}
RME Individual ILCR:	1.3×10^{-5}

I.9.3.3 Risks Under Future Land Use Without Federal Ownership

On-Property Resident Farm Adult (Perched Groundwater)

HI and ILCR values for this receptor are presented in Table I.9-10. The total HI (2.2×10^1) exceeds the benchmark of 1. The ingestion of meat has the highest HI value (1.1×10^1), with the principal contributors being mercury (8.3×10^0) and zinc (1.7×10^0). The ingestion of dairy products has an HI of 5.0, with the principal contributors being silver (2.0×10^0) and boron (1.5×10^0). Ingestion of vegetables and fruits has an HI of 1.9×10^0, with the principal contributors being boron (8.9×10^{-1}) and molybdenum (2.8×10^{-1}). The inhalation pathways has an HI of 2.1×10^0. The dermal contact with soil and incidental ingestion of soil have HIs of 1.3 and 1.2, respectively. The principal target organs impacted for this receptor are the liver (1.65×10^0, cobalt), testis (2.76×10^0, boron), skin (3.05×10^0, arsenic and silver), kidney (9.3×10^0, mercury and cadmium), blood (2.39×10^0), and whole body (5.50×10^{-1}, antimony).

The total ILCR (1.2×10^{-2}) for this receptor exceeds 10^{-4}, with external radiation exposure (1.4×10^{-3}), dermal contact with soils (1.6×10^{-3}), and ingestion of drinking water (7.8×10^{-3}) contributing 90 percent of the total (Table I.9-10). The driving contaminant to the dermal contact exposure is beryllium (1.6×10^{-3}).

On-Property Resident Farm Adult (GMA Water)

A total HI of 2.2×10^1 is predicted for this receptor (Table I.9-11), with ingestion of vegetables and fruits (1.9), inhalation of particulates (2.1), ingestion of meat (11), dermal contact with soils (1.3), incidental ingestion of soils (1.2), and ingestion of dairy products (5.0), all exceeding the target level of 1.0. The principal target organs impacted for this receptor are the liver (1.65×10^0, cobalt), testis (2.76×10^0, boron), skin (3.05×10^0, arsenic and silver), kidney (9.3×10^0, mercury and cadmium), blood (2.39×10^0, zinc), and whole body (5.5×10^{-1}, antimony).

The ILCRs for chemical and radioactive COCs are presented in Table I.9-11. The total ILCR (5.0×10^{-3}) exceeds the target range of 10^{-4} to 10^{-6}. External radiation exposure (1.4×10^{-3}), and dermal contact with soils (1.6×10^{-3}) contribute 60 percent of the total ILCR. The ingestion of radionuclides in drinking water contributes 5.0×10^{-4}. The principal contributors for external radiation are Ra-228 (2.4×10^{-4}) and Ra-226 (7.2×10^{-4}); for dermal contact, beryllium (1.6×10^{-3}); and for the ingestion of radionuclides in drinking water, Tc-99 (3.3×10^{-4}).

TABLE I.9-10

SUMMARY OF POTENTIAL HEALTH EFFECTS: ON-PROPERTY RESIDENT FARM ADULT WHO INGESTS PERCHED WATER (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	2.1×10^{0}
Incidental Ingestion of Soil/Sediment (Chemicals)	1.2×10^{0}
Dermal Contact with Soil/Sediment (Chemicals)	1.3×10^{0}
Ingestion of Meat (Chemicals)	1.1×10^{1}
Ingestion of Dairy Products (Chemicals)	5.0×10^{0}
Ingestion of Vegetables and Fruit (Chemicals)	1.9×10^{0}
RME Individual HI:	2.2×10^{1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	3.8×10^{-5}
Inhalation of Particulates (Radionuclides)	3.0×10^{-4}
Ingestion of Drinking Water (Chemicals)	2.6×10^{-3}
Ingestion of Drinking Water (Radionuclides)	5.2×10^{-3}
Incidental Ingestion of Soil/Sediment (Chemicals)	4.5×10^{-4}
Incidental Ingestion of Soil/Sediment (Radionuclides)	2.0×10^{-4}
Incidental Dermal Contact with Soil/Sediment (Chemicals)	1.6×10^{-3}
Ingestion of Meat (Chemicals)	1.9×10^{-4}
Ingestion of Meat (Radionuclides)	3.4×10^{-6}
Ingestion of Dairy Products (Chemicals)	1.8×10^{-4}
Ingestion of Dairy Products (Radionuclides)	1.3×10^{-5}
Ingestion of Vegetables and Fruit (Chemicals)	5.6×10^{-5}
Ingestion of Vegetables and Fruit (Radionuclides)	1.4×10^{-4}
External Radiation Exposure	1.4×10^{-3}
RME Individual ILCR:	1.2×10^{-2}

TABLE I.9-11
SUMMARY OF POTENTIAL HEALTH EFFECTS:
ON-PROPERTY RESIDENT FARM ADULT WHO INGESTS GMA WATER
(FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	2.1×10^{0}
Ingestion of Drinking Water (Chemicals)	8.5×10^{-2}
Incidental Ingestion of Soil/Sediment (Chemicals)	1.2×10^{0}
Dermal Contact with Soil/Sediment (Chemicals)	1.3×10^{0}
Ingestion of Meat (Chemicals)	1.1×10^{1}
Ingestion of Dairy Products (Chemicals)	5.0×10^{0}
Ingestion of Vegetables and Fruit (Chemicals)	1.9×10^{0}
RME Individual HI:	2.2×10^{1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	3.8×10^{-5}
Inhalation of Particulates (Radionuclides)	3.0×10^{-4}
Ingestion of Drinking Water (Chemicals)	4.8×10^{-25}
Ingestion of Drinking Water (Radionuclides)	5.0×10^{-4}
Incidental Ingestion of Soil/Sediment (Chemicals)	4.5×10^{-4}
Incidental Ingestion of Soil/Sediment (Radionuclides)	2.0×10^{-4}
Dermal Contact with Soil/Sediment (Chemicals)	1.6×10^{-3}
Ingestion of Meat (Chemicals)	1.9×10^{-4}
Ingestion of Meat (Radionuclides)	3.1×10^{-6}
Ingestion of Dairy Products (Chemicals)	1.8×10^{-4}
Ingestion of Dairy Products (Radionuclides)	8.5×10^{-6}
Ingestion of Vegetables and Fruit (Chemicals)	5.6×10^{-5}
Ingestion of Vegetables and Fruit (Radionuclides)	3.1×10^{-5}
External Radiation Exposure	1.4×10^{-3}
RME Individual ILCR:	5.0×10^{-3}

On-Property Resident Farm Child

A total HI of 9.4×10^{-1} is predicted for this receptor (Table I.9-12), with 6 of the exposure pathways exceeding the benchmark of 1.0: inhalation of particulates (5.8), incidental ingestion of soil/sediment (6.0), dermal contact with soil/sediment (2.0), ingestion of meat (19), ingestion of dairy products (53), and ingestion of vegetables and fruit (7.6). The principal target organs impacted for this receptor are the liver (4.63×10^{0}, cobalt), testis (2.05×10^{1}, boron), skin (2.61×10^{1}, arsenic and silver), kidney (2.14×10^{1}, mercury and cadmium), central nervous system (3.00×10^{0}, manganese), blood (1.03×10^{1}, zinc), and whole body (1.53×10^{0}, antimony).

A total ILCR of 8.2×10^{-4} is estimated for this receptor. The highest COC-induced ILCR to this receptor is 2.2×10^{-4} from dermal contact with soil and sediment (chemicals). The following pathways have ILCR values above 1×10^{-6}: inhalation of particulates (chemicals and radionuclides), ingestion of radionuclides in drinking water, incidental ingestion of soil and sediment (chemicals and radionuclides), incidental dermal contact with soil and sediment (chemicals), external radiation, ingestion of meat (chemicals), ingestion of dairy products (chemicals and radionuclides), and ingestion of vegetables and fruits (chemicals and radionuclides).

Off-Property Resident Farm Adult and Child

The results for these two receptors are given in Tables I.9-13 and I.9-14. They are identical to those for the Future Land Use With Federal Ownership scenario.

TABLE I.9-12

SUMMARY OF POTENTIAL HEALTH EFFECTS: ON-PROPERTY RESIDENT FARM CHILD (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	5.8×10^{0}
Ingestion of Drinking Water (Chemicals)	2.0×10^{-1}
Incidental Ingestion of Soil/Sediment (Chemicals)	6.0×10^{0}
Dermal Contact with Soil/Sediment (Chemicals)	2.0×10^{0}
Ingestion of Meat (Chemicals)	1.9×10^{1}
Ingestion of Dairy Products (Chemicals)	5.3×10^{1}
Ingestion of Vegetables and Fruit (Chemicals)	7.6×10^{0}
RME Individual HI:	9.4×10^{1}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	9.1×10^{-6}
Inhalation of Particulates (Radionuclides)	1.6×10^{-5}
Ingestion of Drinking Water (Chemicals)	9.7×10^{-26}
Ingestion of Drinking Water (Radionuclides)	2.2×10^{-5}
Incidental Ingestion of Soil/Sediment (Chemicals)	2.0×10^{-4}
Incidental Ingestion of Soil/Sediment (Radionuclides)	3.3×10^{-5}
Incidental Dermal Contact with Soil/Sediment (Chemicals)	2.2×10^{-4}
Ingestion of Meat (Chemicals)	2.9×10^{-5}
Ingestion of Meat (Radionuclides)	1.0×10^{-7}
Ingestion of Dairy Products (Chemicals)	1.6×10^{-4}
Ingestion of Dairy Products (Radionuclides)	1.7×10^{-6}
Ingestion of Vegetables and Fruit (Chemicals)	1.9×10^{-5}
Ingestion of Vegetables and Fruit (Radionuclides)	2.3×10^{-6}
Direct Radiation Exposure	1.1×10^{-4}
RME Individual ILCR:	8.2×10^{-4}

TABLE I.9-13

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM ADULT (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	1.1×10^{0}
Ingestion of Drinking Water (Chemicals)	4.7×10^{-6}
Ingestion of Meat (Chemicals)	6.8×10^{-7}
Ingestion of Dairy Products (Chemicals)	7.6×10^{-7}
Ingestion of Vegetables and Fruit (Chemicals)	2.9×10^{-6}
RME Individual HI:	1.1×10^{0}

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	1.7×10^{-5}
Inhalation of Particulates (Radionuclides)	5.7×10^{-5}
Ingestion of Drinking Water (Chemicals)	2.2×10^{-28}
Ingestion of Drinking Water (Radionuclides)	1.2×10^{-4}
Ingestion of Meat (Chemicals)	1.5×10^{-10}
Ingestion of Meat (Radionuclides)	1.6×10^{-8}
Ingestion of Dairy Products (Chemicals)	1.6×10^{-10}
Ingestion of Dairy Products (Radionuclides)	2.3×10^{-7}
Ingestion of Vegetables and Fruit (Chemicals)	1.9×10^{-10}
Ingestion of Vegetables and Fruit (Radionuclides)	6.4×10^{-6}
RME Individual ILCR:	2.0×10^{-4}

TABLE I.9-14

SUMMARY OF POTENTIAL HEALTH EFFECTS: OFF-PROPERTY RESIDENT FARM CHILD (FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP)

Exposure Pathway	RME Receptor HI
Inhalation of Particulates (Chemicals)	3.0×10^{0}
Ingestion of Drinking Water (Chemicals)	1.1×10^{-5}
Ingestion of Meat (Chemicals)	1.2×10^{-6}
Ingestion of Dairy Products (Chemicals)	8.0×10^{-6}
Ingestion of Vegetables and Fruit (Chemicals)	1.2×10^{-5}
RME Individual HI: 3.0×10^{0}	

Exposure Pathway	RME Receptor ILCR
Inhalation of Particulates (Chemicals)	4.1×10^{-6}
Inhalation of Particulates (Radionuclides)	2.9×10^{-6}
Ingestion of Drinking Water (Chemicals)	4.3×10^{-29}
Ingestion of Drinking Water (Radionuclides)	5.2×10^{-6}
Ingestion of Meat (Chemicals)	2.3×10^{-11}
Ingestion of Meat (Radionuclides)	5.4×10^{-10}
Ingestion of Dairy Products (Chemicals)	1.5×10^{-10}
Ingestion of Dairy Products (Radionuclides)	4.5×10^{-8}
Ingestion of Vegetables and Fruit (Chemicals)	6.5×10^{-11}
Ingestion of Vegetables and Fruit (Radionuclides)	4.8×10^{-7}
RME Individual ILCR: 1.3×10^{-5}	

I.10.0 UNCERTAINTIES

In relying on multiple assumptions and models, all risk assessments contain elements of uncertainty. The purpose of examining the uncertainty is to provide information relative to the accuracy of the risk estimates and thus aid in the formation of risk management decisions. For the major categories of uncertainty relevant to the CRARE, questions were asked to examine the sources of uncertainty in the risk evaluation:

- COC Selection:

  Are all COCs correctly identified?

- Toxicological Information and Models:

  How good is the current information concerning the toxic properties and dose-response characteristics of the COCs?

- Exposure Pathways:

  Are all potential pathways for transporting contaminants from the site environmental media to the receptors identified?

- Receptor Characterization and Exposure Assumptions:

  Are land use scenarios realistic, and are all potential receptors valid?

- Exposure Point Concentrations:

  Are the models for estimating COC transport from the site media to the receptor, and for estimating the contaminant exposures and intakes, realistic and reasonable?

- Risk Characterization:

  What uncertainties are associated with summing cancer risks or HIs for multiple substances?

A baseline risk assessment uses existing site conditions to estimate current potential exposures and risks. The CRAREs estimate all exposure point concentrations using models and assumptions to estimate postremediation site conditions. Compared to a baseline risk assessment, the CRARE results have much more inherent uncertainty with regard to exposure patterns, exposed populations, and exposure concentrations. Even more important for this Operable Unit 1&2

CRARE, however, is that the remedial alternatives for Operable Units 3 and 5 have not yet undergone a thorough analysis. One purpose of this uncertainty analysis is therefore to identify data quality objectives that have not been met or need to be strengthened. As previously mentioned, this CRARE is the second of four planned reports. Some uncertainties identified in this report will be reduced when subsequent editions of the CRARE are prepared as part of the other operable unit FSs.

I.10.1 COC SELECTION

A major concern in this CRARE is the reliability of COC identification, both in terms of ensuring that all COCs have been identified and that chemical or radionuclides have not been incorrectly identified as COCs. The accuracy of COC identification is directly related to the quality of COC characterization data, including contaminant identification, location, and concentrations. The characterization was defined by the design of the sampling and analysis plan, which described the sampling locations and analytical protocols.

The sources of chemical analytic data for the CRARE were the SWCR (for Operable Units 3 and 5) and the Operable Unit 1, 2, and 4 RI/FS reports. The data in the SWCR were not all obtained through sampling plans designed as part of the CERCLA process. There were three stages of sampling, and the analytical protocols and data validation techniques differed between stages. Consequently, data deficiencies have been identified that must be corrected in the individual operable unit RI, and will be included in their CRAREs when the information becomes available.

It is unlikely that major COC contributors to overall site risk have been overlooked. Despite the described shortcomings of some of the chemical concentration data gathered at the FEMP, there is still a very large and comprehensive database of site contaminant data. The evaluation of these data have identified a large number of contaminants present on the site, and confirm the general pattern of contamination as indicated by past site operations. It is clear that the major contaminants (uranium and other radionuclides, nonradionuclide inorganics, and organics) that could credibly contribute to site risks have been identified. If additional COCs are identified in future RI/FS efforts (which is not likely), they will be included in future CRAREs.

I.10.2 TOXICOLOGICAL INFORMATION AND MODELS

Toxicological information is not operable-unit-specific and therefore is not discussed separately for each operable unit. EPA-supplied RfD values and cancer slope factors were used throughout the risk assessment. Toxicological constants were not derived for any of the COCs evaluated in this CRARE risk assessment. Because of this, the toxicological evaluations (upon which the CRARE risk assessment is based) contribute no more uncertainty than that present in comparable CERCLA documents. However, because this uncertainty arises out of the application of guidelines recommended by the agencies involved, these sources of uncertainty are beyond the control of the FEMP investigation personnel.

There are many sources of uncertainty in the cancer slope factors or unit risks and noncarcinogenic RfD or RfC values provided by the EPA. The three major sources are:

1. Interspecies extrapolations:

   Animal-to-human extrapolation, used in the absence of quantitative pharmacokinetic, 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 very similar in age and genotype, so that intragroup biological variation is minimal. The human population of concern may reflect a great deal of heterogeneity, however, including unusual sensitivity to the COCs.

   Even toxicity data from human occupational exposures 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 estimate is derived) and the quality of the literature databases add to the uncertainty. For carcinogenic effects, the uncertainty associated with some quality factors (e.g., group size) is expressed within the 95 percent upper bound of the slope factor. For noncarcinogenic effects, additional uncertainty factors may be applied in the derivation of the RfD or RfC to reflect the poor quality of the key studies or gaps in the database.

Dermal RfD values and cancer slope factors used in this CRARE were calculated from their corresponding oral values (Section I.7.2). To calculate a dermal RfD, the oral RfD was multiplied by the gastrointestinal absorption efficiency factor, expressed as a fraction. The resulting dermal RfD is based on an absorbed dose, because dermal doses are expressed as absorbed rather than exposure doses. In a similar manner, and for the same reasons, to calculate a dermal cancer slope factor, the oral slope factor was divided by the gastrointestinal adsorption efficiency.

The most important consideration associated with the uncertainty of the calculated dermal RfD values or cancer slope factors is the accuracy of the gastrointestinal absorption efficiency factor. For this reason, the toxicity profiles (Section I.7.6) contain pharmacokinetics discussions in which the oral absorption data were evaluated. Where appropriate, the low (i.e., most conservative) end of the range of available gastrointestinal absorption data for humans was used to derive the dermal RfD or cancer slope factor. When the human data were insufficient, animal data were used. Data from high-dose experiments were not used if more suitable data were available and it appeared the gastrointestinal absorption process could have been saturated. When adequate quantitative data were not located, a default absorption factor was used.

As noted by the EPA (1989a), the absorption of many metals from the gastrointestinal tract is limited, and 0.05 is a reasonable default for metals and inorganic substances. The EPA (1989a) did not recommend a separate default value for organic chemicals. A compilation of data for 19 organic chemicals presented gastrointestinal absorption efficiencies of at least 0.9, indicating that organic chemicals generally are readily absorbed. The arithmetic average of the efficiencies for the 19 organic chemicals, 0.91368 (equivalent to 0.9 when rounded to one significant figure), appears to be a reasonable default gastrointestinal absorption efficiency factor for organic chemicals. The default of 0.9 was used for organic chemicals for which quantitative data were inadequate.

Considerable uncertainty is associated with the 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 would also induce adverse effects in humans. The hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using either the

IARC (1987) or EPA (1986b) approaches. Positive results in animal cancer tests suggest that humans may also exhibit a carcinogenic response, but 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 suggest the nature of the human effects, including the target tissues and type of effects (EPA 1989g).

Another source of uncertainty regarding the quantitative risk estimation for carcinogenicity is the method by which data from high doses in animal 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 nonthreshold assumption of carcinogenesis. An impressive body of evidence, however, suggests that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (Williams and Weisberger 1991). The linear multi-stage model is therefore generally regarded as being extremely conservative for many chemicals.

Adding to the conservativeness of this approach is the fact that the EPA-derived slope factors found in IRIS have been set at the 95 percent UCL of the linear slope of the multi-stage model. Thus, risks estimated using the slope factors may be greatly overestimated. This consideration applies to both radiological and chemical estimates of carcinogenic risk. Of particular concern in this regard are the slope factors derived by EPA for the evaluation of risks due to external exposure to radiation. As discussed in Section I.7.3, these values were derived using very conservative assumptions about exposure conditions, and are likely to provide very 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 were used in deriving RfDs to adjust the results of animal and human toxicologic studies to take into account the nature of the endpoint (NOAEL to LOAEL) seen in the studies, differences in response to different dose schedules, the presence of sensitive populations, and the possible differences between human and animal sensitivity to contaminant exposures. Each uncertainty factor may take a value as high as 10, and thus RfD values for COCs typically have been set between 100 and 1000 times lower than the lowest dose seen 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 sensitive, rather than more sensitive to contaminants), it is the possible that the use of RfDs greatly overstates the potential for adverse health effects in humans.

The level of uncertainty in the toxicologic data for different chemicals varies because information concerning some constituents and their associated health effects is comparatively scarce, while for others much more information is available from health effects studies. Also, different amounts of data may be available concerning the different types of effects for a given COC. For example, uranium has been established as a chemical toxicant (kidneys are the major target organ) based on human and animal studies. The RfD for uranium was based on the results of animal studies and was calculated by applying an uncertainty factor of 1000 to a LOAEL for nephrotoxicity in rabbits to provide a margin of safety for extrapolation to humans. The uncertainty factor consists of three factors of 10 each, for: 1) estimation of a NOAEL from a LOAEL, 2) extrapolation from animals to humans, and 3) the possible range of sensitivities among exposed humans.

There is even greater uncertainty regarding uranium carcinogenicity. As an alpha-particle emitter, uranium is considered to be a carcinogen; however, as discussed in Section I.7.5, epidemiological evidence of uranium-induced excess cancers is very difficult to obtain. This is largely because the human data available on the radiocarcinogenic effects of uranium exposure are for miners who were also simultaneously exposed to radon and its progeny, which are confounding factors. The studies of humans sometimes lack quantitative information concerning uranium exposure, including potential exposure through previous employment, concurrent smoking patterns, or concurrent radon exposure levels, all of which are needed to definitively determine the risk attributable to uranium exposure. These facts weaken the power of the human studies to detect any excess cancer risk. The human studies of cancer from exposure to uranium frequently reveal a slight excess risk, if any, above the natural risk. These uncertainties are not well known or easily quantified.

Uncertainties in the interpretation of toxicologic data especially affect the results of the risk assessment for inhalation exposure to metals. HI values associated with particulate inhalation exceed 1.0 for several receptors. Almost all of the HI values result from estimated exposures to cobalt and manganese via the inhalation pathway. Similarly, boron, cadmium, manganese,

mercury, silver, and zinc are the major contributors to the HI values from exposures via the food pathways.

In the case of cobalt, exposure concentrations result in contaminant intakes that barely exceed the inhalation RfD values. The inhalation RfD for cobalt (3.0×10^{-7} mg/kg/day) was derived using maximum values for all possible uncertainty factors, based on a single epidemiologic study of a disease from exposures to the hard metal and not from cobalt compounds. It is extremely unlikely that humans are actually as sensitive to cobalt exposures as reflected in this RfD. The RfD value is almost certainly well below normal background inhalation exposures received by members of the general population, and the RfD value for cobalt makes it more than one thousand times more toxic than mercury by the inhalation pathway. Thus, a cobalt HQ greater than 1.0 for some populations must be interpreted very cautiously, and probably does not reflect significant concerns over adverse effects.

Chemical speciation is an issue in evaluating the inhalation pathway risk estimates for chromium exposures. From the SWCR, chromium present in soils was assumed to be reported as total chromium. An assumption that this on-site chromium was entirely hexavalent would be inconsistent with the prevailing redox and chemical conditions in environmental media at the FEMP. It is likely that only a small portion of the chromium present (1 percent or less) is actually hexavalent. In this CRARE, it was assumed that 10 percent of the chromium was presented as hexavalent chromium. This failure to adequately characterize on-site chromium species contributes uncertainty to the inhalation pathway risks associated with chromium exposures, since hexavalent chromium species are much more toxic than the trivalent species. Trivalent chromium is not thought to have any carcinogenic activity in humans, whereas the hexavalent chromium compounds are regarded as potent human carcinogens.

I.10.3 EXPOSURE PATHWAYS

The exposure pathways evaluated within the CRARE risk assessment were initially proposed in the SWCR and further reviewed during the Operable Unit 1, 2, and 4 RIs. The major source of uncertainty in predicting future exposures at the FEMP is the future disposition of the property itself. Because it is not possible to accurately predict future land uses or the condition of the site, conservative (rather than the most likely) future conditions were evaluated, as stipulated by the

NCP. It has been assumed that the FEMP would not become a residential area. This is a conservative assumption, as the farm scenarios used in this CRARE have a greater chance of excess exposure due to the inclusion of the indirect pathways of vegetable, beef, and milk consumption.

In future CRAREs, additional data will be gathered to support a more detailed evaluation of the indirect human exposure pathways. Depending on the findings of the RI/FS for the other operable units, the evaluation of the indirect pathways may be expanded to include contributions to exposure concentrations through other transport mechanisms (particulate deposition, surface water runoff), as well as the possible inclusion of additional groundwater COCs that may be subject to bioconcentration.

I.10.4 RECEPTOR CHARACTERIZATION AND EXPOSURE ASSUMPTIONS

Receptor characterization is not operable-unit-specific and therefore is not discussed separately for each operable unit. The default values for characterizing FEMP receptors are presented in the RAWPA (DOE 1992i). For this CRARE, receptor scenarios (one Current and two Future Land Use scenarios) were selected to represent the reasonable maximum potential exposure. 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 most of this distribution, this risk assessment follows the EPA's recommendation to use the 95th percentile for most exposure factors. In addition, the exposure factors are consistent with EPA Region V guidance. This introduces a conservative bias into the results.

As previously stated, the following RME receptors were chosen for this CRARE:

- Groundskeeper
- Trespassing child
- Expanded trespasser
- Off-property resident farm adult and child
- On-property resident farm adults (two) and child

Other receptors may be exposed to FEMP COCs; however, the conservative exposure scenarios addressed in this report make it likely that no actual exposed population will receive greater exposures than those estimated in the CRARE. A brief discussion of the uncertainty in selected exposure factors follows.

I.10.4.1 Exposure Duration

For FEMP risk assessments, it was assumed that the farm residents would occupy the land for a full lifetime exposure period (70 years). This is a conservative approach, but at most it overestimates the risk by a factor of three relative to representative residential tenure in the area. It was also assumed that all workers would occupy their jobs for 25 years, a realistic estimate of exposure duration given the stability of the surrounding communities.

I.10.4.2 Exposure Frequency

It was assumed the farm residents would occupy the property for 350 days per year, a realistic assumption, especially for a farming family. Likewise, workers were assumed to work for 250 days a year, the normal number of annual workdays. What is uncertain, however, is the number of days a trespassing child or expanded trespasser would be on FEMP property. The assumptions were 52 days for the trespassing child, 110 days for the expanded trespasser as a youth and 40 days as an adult. These are conservative but reasonable assumptions and only moderately affect the results of the risk assessment.

I.10.4.3 Exposure Time

The farm residents were assumed to spend 24 hours per day on the property. This is a slightly conservative assumption as it does not take into account school time, shopping time, work, and other activities. What is uncertain is the time a worker, trespassing child, or expanded trespasser would spend in contact with the property media. The exposure times chosen are realistic but could underestimate the exposure. The most-effected pathways are direct contact and inhalation.

I.10.4.4 Body Weight

The body weights used in this CRARE were derived from standard tables for U.S. body-weight distributions. The values were selected from the distribution midpoints because of the uncertainty regarding those distributions. Individual variances for adults are likely to be less than a factor of 2. And although children have a wide range of body weights, the uncertainty is at most a factor of 2 or 3 (plus or minus).

I.10.4.5 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, 200 mg/day for children under the age of 6, and 50 mg/day for an industrial worker not engaged in construction work. Since the FEMP risk assessments also considered a farmer who would be exposed to great quantities of dust through farming activities, a value of 180 mg/day was used. These values are realistic as a multi-year average, but the soil ingestion rates could potentially be much higher for shorter-term exposures. If anything, these ingestion rates may be underestimated, but by less than a factor of 2 for multi-year exposures.

The consumption of drinking water was set to the EPA Region V default values, which are conservative estimates. Over multi-year exposures, these values are not likely to vary widely and may be overestimated by a factor of less than 2. Most likely, the consumption of drinking water will be less than the default values.

The rate and type of food consumption vary greatly from locality to locality and from individual to individual. The estimates of food consumption used in the FEMP risk assessments are national averages and may not be appropriate for some of the individuals exposed to FEMP COCs. The values presented represent conservative estimates and are not likely to vary by more than a factor of 2 for the average individual. It was assumed that 50 percent of the fruit and vegetables, and 100 percent of the meat and milk in the farm residents' diet would consist of products from their farm. This may overestimate the risk from fruit and vegetable consumption. The risk from meat and milk consumption may be overestimated by a factor of 3. The greatest uncertainty is in the assumption of food consumption for children. The direction and magnitude of uncertainty are unknown.

I.10.4.6 Dermal Exposure Factors

Four critical assumptions have been made relating to the assessment of dermal exposure to soils: 1) the amount of exposed skin surface area, 2) the quantity of soil adhering to the skin, 3) the length of time the soil adheres to the skin, and 4) the partitioning rate of the COC from the soil across the skin barrier. The four factors vary widely from individual exposure to exposure and may contribute substantially to the uncertainty in risk assessment of these pathways. In general, the assumptions used to estimate dermal absorption are consistent with the conservative default

values defined in recent EPA guidance. In addition, the adjustment of toxicity values for use in the dermal pathway risk assessment, particularly in the case of inorganic contaminants, was performed using conservative assumptions about contaminant intake, and likely contributes a further degree of conservatism to the characterization of dermal pathway risks.

I.10.4.7 Inhalation Exposure

Multiple breathing rates were used in estimating doses via inhalation. The receptors are typical for different exposed groups, including small children, adults at home, and adults at work. Each of these receptors has a wide range of breathing rates, which vary on a daily basis. The extent of the range is a factor of 3 for any defined level of activity. The breathing rates chosen for this evaluation are at the upper end of the distribution but do not represent the maximum.

I.10.5 EXPOSURE POINT CONCENTRATIONS

The values used to represent exposure point concentrations were designed to provide conservative estimates of exposure, thus ensuring a conservative evaluation of the risk. All CRARE exposure point soil concentrations are projected to be cleanup levels, existing soil concentrations, or modeled values, except for Operable Units 1 and 2, which are proposed to be capped (clean soil was assumed with no contaminants present). The uncertainty of exposure point concentrations estimated by models depends on input parameters (diffusion coefficients, groundwater flow, air flow, etc.), model characteristics, release mechanisms, and source terms. CRARE input parameters were based on site information together with professional judgment and were designed to be conservative. The input parameters and models were based on the RAWPA and SWCR. The exposure parameters were taken from the Operable Unit 1 RI.

I.10.5.1 Air Concentrations

The major contributors to uncertainty in CRARE air modeling are the release estimates for particulate and gaseous (radon) emissions and the concentrations and extent of COCs in the surface soil. The components of uncertainty include:

- Wind speed and direction
- Climate conditions (temperature, moisture, etc.)
- Surface soil COC concentrations

- Release of particulates to the air from soils, including frictional velocity concerns
- Volatilization
- Radon release

The uncertainties associated with variations in meteorologic and climatologic conditions are contained to a large degree in the air quality models used to evaluate contaminant transport. Five years of actual climatic data from the site provide a large database upon which long-term air quality modeling can be based. The overall level of uncertainty associated with the meteorologic models is probably relatively low relative compared to the contribution of other factors.

The particulate COC concentrations depend on the estimated surface soil contamination, soil characteristics, and the percentage of vegetative cover. The estimated surface soil concentrations in Operable Units 1, 2, 4, and 5 were fixed at the cleanup levels for COCs that initially exceeded those levels. The COCs affected by this step were Cs-137 and Np-237, as well as isotopes of radium, thorium, and uranium. For COCs not affected by this step, the RI/FS database was preferentially used to characterize exposed soil concentrations in Operable Units 1, 2 and 5. The Operable Unit 2 RI, Operable Unit 4 RI, and Operable Unit 4 FS were also used as sources of exposed soil concentrations since these reports conveniently summarized RI/FS data for the given operable unit. The exposed soil COC concentrations were based on UCL values for the areas in which the COC concentration had not been reset to the cleanup level. Not all COC soil concentrations were characterized for all areas. When concentration data were not available for a given source, the contribution to the COC air concentration from that source was not calculated. The overall approach is considered realistic, with some potential for underestimation due to the lack of COC data for several source areas.

The vegetative cover for the surface areas was assumed to be at 85 percent, which is realistic for this area of southern Ohio. In fact, using 85 percent may underestimate the dust production if the FEMP becomes a farm.

The controlling factors in radon air concentrations are the extent of Ra-226 in the surface soils and the layers of cover for the capped area. As previously stated, the extent of Ra-226 contamination in the surface soils is incompletely characterized, as are the data concerning the

fate of Ra-226 after soil washing. It was assumed that all capped areas would remain intact for 1000 years and no significant radon release would occur from the capped areas or disposal facilities. Overall, the predicted air concentrations are realistic but not conservative.

The methods used to combine the particulate generation and air quality models may also contribute significantly to the uncertainty in the inhalation pathway risk assessment. As discussed in Section I.6.0, the particulate emission rate was determined using the unlimited erosion potential equation from EPA's *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites* developed for estimated annual PM_{10} emission rates from the annual mean wind speed. The equation used includes a distribution function which accounts for actual winds ranging above and below the annual mean wind speed. The use of this equation with the ISCLT2 model may overestimate emissions for the lower wind speeds. Since the frequency of wind speed in the lower-speed categories is much greater than in the upper-speed categories, using a single emission rate for all categories tends to overestimate ground-level PM_{10} concentrations.

The use of the unlimited erosion potential equation was based on the particle size distribution of surface soil. The equation does not account for moisture content, crustiness of the surface, and nonerodible elements present on the surface. The FEMP surface is probably more characteristic of an area with "limited" erosion potential: an inhomogeneous field covered with gravel, rocks, or clumps of vegetation that has a moderate moisture content and tends to form a hard crust when dried and/or frozen. The bias of using the unlimited erosion potential equation is clearly in the conservative direction.

I.10.5.2 Surface Water and Groundwater Concentrations

The need to predict surface water and groundwater concentrations for 1000 years into the future represents a major source of uncertainty in the CRARE. In evaluating future water concentrations, the same models were used as in the baseline risk assessment (MUSLE, ODAST, and SWIFT III). The use of MUSLE was modified to incorporate data from two additional models, HEC-1 and VS2DT. The level of uncertainty associated with the modeling is large but cannot be easily quantified. Table I.10-1 identifies the major parameters used in the CRARE modeling and provides estimates of their relative effect on the loading of COCs to the aquifer.

TABLE I.10-1

MAJOR PARAMETERS IN CRARE MODELING AND THEIR EFFECT ON AQUIFER LOADING

Parameter	Concentration[a]	Time[b]	Duration[c]	Confidence[d]
Source Term				
Quantities in Wastes			Medium+	Medium
Concentration in Wastes	Major+			Medium
Quantities in Soils			Medium+	Medium
Concentration in Soils	Major+			Medium
Surface Runoff Models				
K_d of Soils	Major–			Low
R_t - Total Storm Rainfall	Major–			Low
T_f - Storm Duration	Small–			Low
D_d - Overland Distance		Small+		High
K - Soil Erodibility Factor	Small+			Low
λ - Source Decay Factor	Small–		Small–	Hi/Low
Vadose Zone Models (HELP, ODAST)				
D - Dispersion Coefficient	Small–		Small+	Low
V - Seepage Velocity		Medium–	Major–	Low
R - Retardation Factor	Small–	Major+		Low
α - Depletion Factor			Medium–	Low
T_o - Depletion Time			Major+	Low
λ - Source Decay Factor	Small–		Small–	Hi/Low
Aquifer Model (SWIFT)				
H_H - Horizontal Conductivity	Medium–	Medium–		Medium
K_v - Vertical Conductivity	Medium–	Medium–		Low
α_H - Horizontal Dispersivity	Medium–	Medium–		Low
α_T - Transverse Dispersivity	Small–	Small–		Low
R - Retardation Factor	Medium+	Major+		Low

[a]Maximum level of concentration in the aquifer.
[b]Time of occurrence of peak concentration in the aquifer.
[c]Time duration of release.
[d]Level of confidence in parameter values.
[e]High level of confidence in decay factors for radionuclides and low level of confidence in decay factors for organic contaminants.

+ = Small, medium, or major positive effect, i.e., increase in parameter value will increase the value of the dependent variable.
– = Small, medium, or major negative effect, i.e., increase in parameter value will decrease the value of the dependent variable.

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To be conservative, a method was developed to determine both the location and the 10-year interval over which the greatest ILCR was estimated for an adult RME receptor. This receptor was assumed to ingest 2 liters of groundwater per day over a 70-year lifetime. For each 10-year interval of the groundwater modeling output, and for each potential receptor location, the ILCR was estimated for each modeled COC (which had an appropriate cancer slope factor). The resulting individual cancer risks were summed for each location over the 10-year interval. The single location where the RME receptor would experience the greatest total ILCR (over each 70 or 1000 years of groundwater modeling output) was selected as the representative receptor location for each scenario.

The exposure concentration for perched groundwater was the lower of either the 95 percent UCL of on-site concentrations or 100 times the MCL for uranium and technetium reported in the SWCR. Both of these health-conservative approaches probably overestimate potential future exposures.

Other components of uncertainty in the water modeling are the partitioning coefficient (K_d) values of COCs in the vadose zone and the aquifer, and the source terms for release. The K_d uncertainty is of most importance when modeling over hundreds of years. The vadose layers provide a time delay to contamination reaching the aquifer, except that in the model, the contamination in surface runoff is assumed to reach the aquifer without delay. This delay in the vadose zone transport is evidenced by time shifting of the peak concentration in the aquifer. The two vadose layers are essentially in series (e.g., contamination must pass through vadose layers 1 and 2 before reaching the aquifer). The average travel time, T_n, through each layer is:

$$T_n = \frac{R_n L_n}{V_n} \qquad (1)$$

where

n = layer,
R_n = retardation factor = $1 + \frac{K_d \rho_b}{\theta}$ for layer n,

L_n = thickness of layer,
V_n = seepage velocity in layer n,
ρ_b = bulk density, and
θ = moisture content.

Thus, the travel time in each layer is directly proportionate to the K_d of that layer. For many contaminants, the K_d of vadose layer 1 is much larger than that of layer 2. The K_d can vary according to the COC chemistry, the pH of water, concentrations of other components (chloride, sulfate, etc.), and soil characteristics (sand, clay, porosity, etc.). The K_d values for this CRARE were generally based on site-specific data or values from the literature, as summarized in the RAWPA. The uncertainty would be reduced by determining additional operable-unit-specific K_d values.

Additional uncertainty derives from the release mechanisms of the sources into the vadose zone. An important component in the release mechanism is the exfiltration rate (the rate at which the water moves through the source area). Engineering calculations and/or HELP modeling were used to estimate this rate for the engineered areas.

The major operable-unit-specific sources of groundwater uncertainty with respect to source terms are summarized as follows:

- Operable Unit 1:

  Magnitude and location of COCs, and exfiltration rate.

- Operable Unit 2:

  Magnitude of COCs, cap design, and exfiltration rate.

- Operable Unit 3:

  Little information is available on the nature, magnitude, and location of COCs beneath and within the buildings; in general, the concentrations of COCs are uncertain. The vault design and exfiltration rate are also uncertain.

- Operable Unit 4:

  Uncertainty in the concentrations and distributions of subsurface COCs.

- Operable Unit 5:

  Site-wide surface soil contamination and perched water plume are not well-characterized. Characteristics of flow and transport in the vadose zone are probably more complex than modeled by ODAST. The extent of floral and faunal contamination and the geochemistry of water percolating through the remediated soils have not been well established.

To reduce the uncertainty associated with characterizing flow and transport in the vadose zone, the Operable Unit 5 staff is currently conducting a multi-faceted field investigation that includes slug and pumping tests, lysimeter installation and sampling, packer tests, and yield tests. This program is described further in Parsons (1993). The Operable Unit 5 staff is also evaluating whether the ODAST model should be replaced with a 2- or 3-dimensional model.

I.10.6 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. Uncertainties associated with summing cancer risks or HIs for multiple substances are of particular concern in the risk characterization step. The assumption of dose additivity ignores possible synergisms or antagonisms among chemicals and assumes similarity in mechanisms of action and metabolism. However, data 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. These assumptions are made to help prevent an underestimation of cancer risk or potential noncancer health effects at a site (EPA 1986, 1989).

I.10.7 SUMMARY

As subsequent CRAREs are completed, major sources of uncertainty will be further characterized and possible courses of action will be developed to reduce overall uncertainty.

I.11.0 SUMMARY OF METHODOLOGY AND RESULTS

This Operable Unit 1&2 CRARE presents a risk evaluation for all FEMP COCs transported via the direct pathways of air, soil, groundwater, surface water, and radiation, as well as the indirect pathway of farm product consumption. The results have been summarized in this section by the following categories:

- Site-wide sources of contamination
- Identification of COCs
- Receptor characterization
- Pathways of exposure
- Postremediation residual risk characterization
- Operable unit contribution to risk
- Impact of uncertainty on the risk estimates

I.11.1 METHODOLOGY

I.11.1.1 Site-Wide Sources of Contamination

The primary sources of contamination remaining after site remediation include the vaults, operable unit residual footprints, site soil, and the capped/covered areas of Operable Units 1 and 2. The site soil is the major source for all risk estimates. Section I.11.7 discusses the uncertainties associated with these sources of residual risk.

I.11.1.2 Identification of COCs

Potential COCs detected on-property were identified using Appendix R of the SWCR, and the Operable Unit 1, 2, and 4 RI/FS reports. A multi-step screening process identified those COCs that would be present on FEMP property during the 70- and 1000-year postremediation time frames. Volatile organic chemicals were eliminated from consideration as COCs because evaporation would rapidly remove these compounds from the FEMP during the time periods under evaluation. Similarly, other organic compounds were removed from consideration after evaluating their organic decay rates in water and soil.

The remaining COCs (presented in Section I.4.0) were then used in fate and transport modeling of air, surface water, groundwater, and farm products. During the groundwater fate and transport analysis (Section I.6.0), the COCs were further screened using preliminary techniques to

determine if significant quantities of COCs would reach groundwater within the 1000-year time frame. It is unlikely that any major COCs were overlooked.

The detailed risk analysis indicates that the major radionuclides of concern are U-238, U-234, Th-228, Rn-222, Ra-228, and Pb-210. The principal contributors to the carcinogenic risk are arsenic, beryllium, chromium, and the PCBs. The principal contributors to the noncarcinogenic HI are antimony, arsenic, boron, cobalt, manganese, mercury, molybdenum, silver, and zinc.

I.11.1.3 Receptors

The following on-property and off-property RME receptors have been evaluated this CRARE.

On-Property	Off-Property
• Resident farm adult (who ingests GMA water)	• Resident farm adult
• Resident farm adult (who ingests perched water)	• Resident farm child
• Resident farm child	
• Expanded trespasser	
• Trespassing child	
• Groundskeeper	

These receptors represent a wide array of potential land uses. Even though the FEMP was not evaluated for residential-only land use, it must be pointed out that the use of resident farm receptors (who consume the farm produce) is more conservative than the use of a residential-only receptor. For the evaluation of carcinogenic risk, all adult farmers were assumed to be exposed for their entire 70-year life spans.

The carcinogenic risk estimate for the on-property resident farmer is the most elevated and exceeds the target risk range of 10^{-4} to 10^{-6}. The ingestion of perched groundwater would increase the ILCR by more than 30 percent for this receptor. Risks for the trespassing child and expanded trespasser are within the target range for both carcinogenic and noncarcinogenic effects. Risks for the groundskeeper are above the target range for both carcinogenic and noncarcinogenic health effects. Carcinogenic risks for the off-property farm adult and child

exposure scenarios are within the target risk range. The off-property farm adult and child are above the noncarcinogenic HI benchmark of 1.

I.11.1.4 Pathways

The pathways considered in this CRARE are:

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

For this CRARE, the major pathways of concern were found to be the inhalation of fugitive particulates, the consumption of drinking water, and dermal contact with soils. External radiation was a significant pathway of concern for all on-property receptors. The major uncertainty relating to the inhalation pathway is the resuspension rate of fugitive particulates. The specific concern for this factor is discussed in Section I.11.7.

I.11.2 POSTREMEDIATION RESIDUAL RISK RESULTS

The estimated risks from the FEMP are summarized in Table I.11-1 and presented in graphical format in Figure I.11-1. Tables I.11-2 through I.11-4 have been developed to further illustrate the risks associated with the selected on- and off-property activities by pathways and subsequent major contributing COCs. Table I.11-5 presents an analysis of major target organs impacted when HIs were greater than the benchmark of 1. The adult farm resident has been selected to represent the on- and off-property resident under all three scenarios. The adult off-property resident has not been included under the Future Land Use Without Federal Ownership scenario as the risk is the same as under the Future Land Use With Federal Ownership scenario. The residential risks from the remediated FEMP are summarized as follows.

TABLE I.11-1

SUMMARY OF ILCR AND HI FOR ALL RECEPTORS, ALL SCENARIOS

Current Land Use

RME Receptor	ILCR	HI
Groundskeeper	1.4×10^{-4}	1.1×10^{0}
Trespassing Child	1.1×10^{-5}	1.2×10^{-1}
Off-Property Farm Residents		
Adult	1.2×10^{-4}	1.1×10^{0}
Child	9.0×10^{-6}	3.0×10^{0}

Future Land Use With Federal Ownership

RME Receptor	ILCR	HI
Expanded Trespasser	3.3×10^{-5}	2.4×10^{-1}
Trespassing Child	1.1×10^{-5}	1.2×10^{-1}
Off-Property Farm Residents		
Adult	2.0×10^{-4}	1.1×10^{0}
Child	1.3×10^{-5}	3.0×10^{0}

Future Land Use Without Federal Ownership

RME Receptor	ILCR	HI
On-Property Farm Residents		
Adult (ingests perched groundwater)	1.2×10^{-2}	2.2×10^{1}
Adult (ingests GMA water)	5.0×10^{-3}	2.2×10^{1}
Child	8.2×10^{-4}	9.4×10^{1}
Off-Property Farm Residents		
Adult	2.0×10^{-5}	1.1×10^{0}
Child	1.3×10^{-6}	3.0×10^{0}

GMA = Great Miami Aquifer

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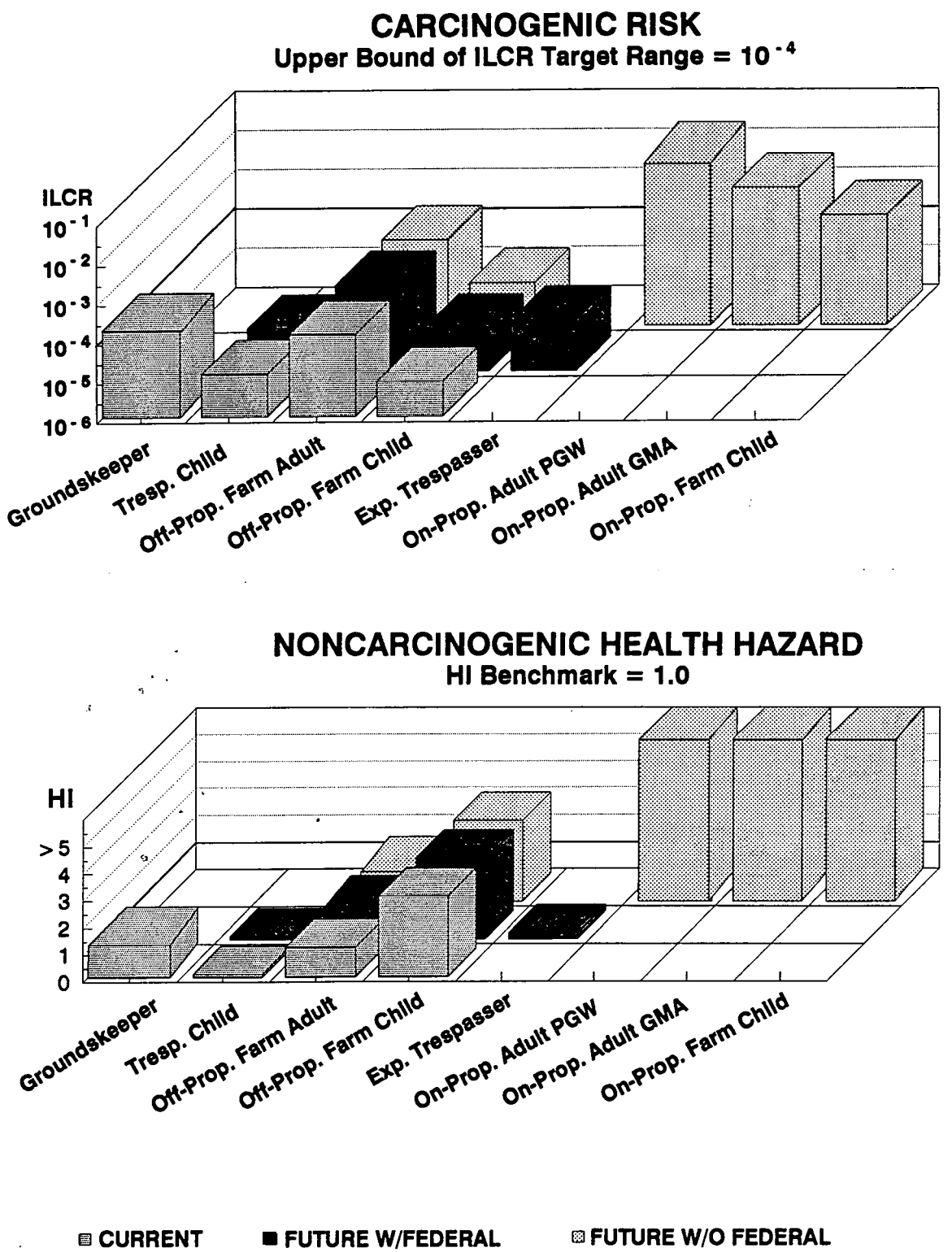

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FIGURE 1.11-1
SUMMARY OF RECEPTOR HAZARDS AND RISKS

TABLE I.11-2

PATHWAY RISKS: CURRENT LAND USE SCENARIO

	Groundskeeper		Trespassing Child		Off-Property Farm Adult	
Pathway	**HI**	**ILCR**	**HI**	**ILCR**	**HI**	**ILCR**
Inhalation	Co 6.1×10^{-1} Ba 1.7×10^{-2} Mn 1.4×10^{-1}	As 5.6×10^{-7} Cr 3.5×10^{-6} U-236 1.8×10^{-6} U-234 7.8×10^{-6} Rn-222 2.6×10^{-6} Th-230 9.4×10^{-7}	Co 3.4×10^{-2} Mn 7.7×10^{-3}	Cr 9.4×10^{-8} U-236 3.0×10^{-8} U-234 1.3×10^{-7} Rn-222 4.2×10^{-8}	Co 8.5×10^{-1} Mn 1.9×10^{-1}	As 2.2×10^{-6} Cr 1.4×10^{-5} Rn-222 1.0×10^{-5} U-234 3.0×10^{-5} U-236 7.1×10^{-6}
Subtotal:	7.6×10^{-1}	1.9×10^{-5}	4.3×10^{-2}	3.6×10^{-7}	1.1×10^{0}	7.4×10^{-5}
Ingestion (Soil)	Sb 1.3×10^{-2} As 1.7×10^{-2} Mn 6.8×10^{-3} Tl 6.8×10^{-3}	As 3.2×10^{-6} Be 1.1×10^{-6} Pb-210 4.3×10^{-7} U-234 2.1×10^{-7} U-238 2.4×10^{-7}	Sb 1.1×10^{-6} As 1.4×10^{-3} Mn 5.8×10^{-4} Tl 5.8×10^{-4}	As 1.3×10^{-7} Be 4.6×10^{-8} Pb-210 1.1×10^{-8} U-234 5.1×10^{-9} U-238 6.0×10^{-9}	NA	NA
Subtotal:	6.1×10^{-2}	5.4×10^{-6}	5.2×10^{-3}	2.1×10^{-7}		
Dermal (Soil)	Sb 5.0×10^{-2} B 1.4×10^{-2} Cd 3.9×10^{-2} Mn 1.3×10^{-1} Hg 1.3×10^{-2}	Be 6.5×10^{-5}	Sb 1.2×10^{-2} Cd 9.7×10^{-3} Mn 3.2×10^{-2}	Be 7.7×10^{-6}	NA	NA
Subtotal:	2.7×10^{-1}	6.5×10^{-5}	6.8×10^{-2}	7.7×10^{-6}		
Drinking Water	NA	NA	NA	NA	Sb 2.1×10^{-5}	U-234 7.3×10^{-6} U-238 7.6×10^{-6} Tc-99 2.6×10^{-5}
Subtotal:					2.1×10^{-5}	4.1×10^{-5}
Ingestion (Meat)	NA	NA	NA	NA	Tl 2.4×10^{-7} Hg 2.6×10^{-7}	U-234 2.7×10^{-9} U-238 2.9×10^{-9}
Subtotal:					7.1×10^{-7}	5.8×10^{-9}
Ingestion (Dairy)	NA	NA	NA	NA	Ag 1.1×10^{-7} U 5.0×10^{-7}	U-234 3.9×10^{-9} U-238 4.1×10^{-8}
Subtotal:					7.7×10^{-7}	8.2×10^{-8}
Ingestion (Vegetables and Fruit)	NA	NA	NA	NA	U 2.2×10^{-6}	U-234 1.1×10^{-6} U-238 1.1×10^{-6}
Subtotal:					2.9×10^{-6}	2.3×10^{-6}
External Radiation	NA	Ra-226 1.3×10^{-5} Ra-228 1.1×10^{-5} Th-228 1.3×10^{-5}	NA	Cs-137 3.3×10^{-7} Ra-226 6.8×10^{-7} Ra-228 5.8×10^{-7} Th-228 6.4×10^{-7} U-238 1.4×10^{-7}	NA	NA
Subtotal:		4.8×10^{-5}		2.5×10^{-6}		
Ingestion (Wading)	NA	NA	NA	Tc-99 1.3×10^{-9}	NA	NA
Subtotal:				1.5×10^{-9}		
Receptor Total:	1.1×10^{0}	1.4×10^{-4}	1.2×10^{-1}	1.1×10^{-5}	1.1×10^{0}	1.2×10^{-4}

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TABLE I.11-3

PATHWAY RISKS: FUTURE LAND USE WITH FEDERAL OWNERSHIP

	Expanded Trespasser				Off-Property Farm Adult			
Pathway	HI		ILCR		HI		ILCR	
Inhalation	Co	4.0×10^{-2}	Cr	1.3×10^{-7}	Co	8.5×10^{-1}	As	2.2×10^{-6}
	Mn	9.0×10^{-3}	Rn-222	6.7×10^{-8}	Mn	1.9×10^{-1}	Cr	1.4×10^{-5}
			U-234	2.0×10^{-7}			Rn-222	1.0×10^{-5}
			U-236	4.7×10^{-8}			U-234	3.0×10^{-5}
							U-236	7.1×10^{-6}
Subtotal:		5.0×10^{-2}		5.4×10^{-7}		1.1×10^{0}		7.4×10^{-5}
Ingestion (Soil)	As	1.8×10^{-3}	As	2.2×10^{-7}				
	Mn	7.5×10^{-4}	Be	7.8×10^{-8}		NA		NA
	Sb	1.4×10^{-3}	Pb-210	2.3×10^{-8}				
	Tl	7.5×10^{-4}	U-234	1.1×10^{-8}				
			U-238	1.3×10^{-8}				
Subtotal:		6.7×10^{-3}		3.6×10^{-7}				
Dermal (Soil)	Cd	2.7×10^{-2}	Be	3.0×10^{-5}				
	Mn	8.9×10^{-2}				NA		NA
	Sb	3.4×10^{-2}						
Subtotal:		1.9×10^{-1}		3.0×10^{-5}				
Drinking Water		NA		NA	Sb	4.7×10^{-6}	U-234	2.1×10^{-5}
							U-238	2.2×10^{-5}
Subtotal:						4.7×10^{-6}		1.2×10^{-4}
Ingestion (Meat)		NA		NA	Hg	2.6×10^{-7}	U-234	7.7×10^{-9}
					Tl	2.4×10^{-7}	U-238	8.1×10^{-9}
Subtotal:						6.8×10^{-7}		1.6×10^{-8}
Ingestion (Dairy)		NA		NA	U	5.0×10^{-5}	U-234	1.1×10^{-7}
					Ag	1.1×10^{-7}	U-238	1.2×10^{-7}
Subtotal:						7.6×10^{-7}		2.3×10^{-7}
Ingestion (Vegetables and Fruit)		NA		NA	U	2.2×10^{-6}	U-234	3.1×10^{-6}
							U-238	3.2×10^{-6}
Subtotal:						2.9×10^{-6}		6.4×10^{-6}
External Radiation		NA	Cs-137	2.5×10^{-7}				
			Th-228	4.9×10^{-7}		NA		NA
			Ra-226	5.2×10^{-7}				
			Ra-228	4.4×10^{-7}				
Subtotal:				1.9×10^{-6}				
Ingestion (Wading)		NA	Tc-99	2.5×10^{-8}				
			U-234	7.0×10^{-9}		NA		NA
			U-238	7.4×10^{-9}				
Subtotal:				4.0×10^{-8}				
Receptor Total:		2.4×10^{-1}		3.3×10^{-5}		1.1×10^{0}		2.0×10^{-4}

TABLE I.11-4

PATHWAY RISKS: FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP[a]

	On-Property Farm Adult (Ingests Perched Groundwater)				On-Property Farm Adult (Ingests GMA Water)			
Pathway	HI		ILCR		HI		ILCR	
Inhalation	Co	1.7×10^{0}	Cr	2.9×10^{-5}	Co	1.7×10^{0}	Cr	2.9×10^{-5}
	Mn	3.8×10^{-1}	Rn-222	2.5×10^{-5}	Mn	3.8×10^{-1}	Rn-222	2.5×10^{-5}
			U-234	2.2×10^{-4}			U-234	2.2×10^{-4}
			U-236	1.5×10^{-5}			U-236	1.5×10^{-5}
Subtotal:		2.1×10^{0}		3.4×10^{-4}		2.1×10^{0}		3.4×10^{-4}
Ingestion (Soil)	As	7.4×10^{-1}	As	4.0×10^{-4}	As	7.4×10^{-1}	As	4.0×10^{-4}
	Sb	1.7×10^{-1}	Be	5.0×10^{-5}	Sb	1.7×10^{-1}	Be	5.0×10^{-5}
			Pb-210	5.7×10^{-5}			Pb-210	5.7×10^{-5}
			U-234	5.3×10^{-5}			U-234	5.3×10^{-5}
Subtotal:		1.2×10^{0}		6.5×10^{-4}		1.2×10^{0}		6.5×10^{-4}
Dermal (Soil)	Mn	4.0×10^{-1}	Be	1.6×10^{-3}	Mn	4.0×10^{-1}	Be	1.6×10^{-3}
	Sb	3.7×10^{-1}			Sb	3.7×10^{-1}		
	B	1.1×10^{-1}			B	1.1×10^{-1}		
Subtotal:		1.3×10^{0}		1.6×10^{-3}		1.3×10^{0}		1.6×10^{-3}
Drinking Water		NA	Arocl-1221	2.6×10^{-3}	Sb	8.5×10^{-2}	Tc-99	3.3×10^{-4}
			Np-237	3.6×10^{-3}			U-234	7.9×10^{-5}
			Tc-99	1.1×10^{-3}			U-238	8.2×10^{-5}
			U-234	2.4×10^{-4}				
			U-238	2.6×10^{-4}				
Subtotal:				7.8×10^{-3}		8.5×10^{-2}		5.0×10^{-4}
Ingestion (Meat)	Hg	8.3×10^{0}	Arocl-1254	6.0×10^{-5}	Hg	8.3×10^{0}	Arocl-1254	6.0×10^{-5}
	Zn	1.7×10^{0}	Arocl-1260	7.6×10^{-5}	Zn	1.7×10^{0}	Arocl-1260	7.6×10^{-5}
			As	4.7×10^{-5}			As	4.7×10^{-5}
Subtotal:		1.1×10^{1}		1.9×10^{-4}		1.1×10^{1}		1.9×10^{-4}
Ingestion (Dairy)	Ag	2.0×10^{0}	Arocl-1254	7.5×10^{-5}	Ag	2.0×10^{0}	Arocl-1254	7.5×10^{-5}
	B	1.5×10^{0}	Arocl-1260	9.6×10^{-5}	B	1.5×10^{0}	Arocl-1260	6.1×10^{-5}
	Zn	6.6×10^{-1}	U-238	6.1×10^{-6}	Zn	6.6×10^{-1}	U-238	2.0×10^{-6}
Subtotal:		5.0×10^{0}		1.9×10^{-4}		5.0×10^{0}		1.8×10^{-4}
Ingestion (Vegetables and Fruit)	B	8.9×10^{-1}	Arocl-1254	1.5×10^{-5}	B	8.9×10^{-1}	Arocl-1254	1.5×10^{-5}
	Mo	2.8×10^{-1}	As	2.0×10^{-5}	Mo	2.8×10^{-1}	As	2.0×10^{-5}
			Be	1.2×10^{-5}			Be	1.2×10^{-5}
			U-234	1.3×10^{-5}			U-234	1.3×10^{-5}
			U-238	1.2×10^{-4}			U-238	1.3×10^{-5}
Subtotal:		1.9×10^{0}		2.0×10^{-4}		1.9×10^{0}		8.7×10^{-5}
External Radiation		NA	Ra-226	7.2×10^{-4}		NA	Ra-226	7.2×10^{-4}
			Ra-228	2.4×10^{-4}			Ra-228	2.4×10^{-4}
Subtotal:				1.4×10^{-3}				1.4×10^{-3}
Ingestion (Wading)		NA		NA		NA		NA
Subtotal:								
Receptor Total:		2.2×10^{1}		1.2×10^{-2}		2.2×10^{1}		5.0×10^{-3}

LEGEND:
For Tables I.11-2 through I.11-4.

	On-Property Farm Adult			
Pathway	HI		ILCR	
Inhalation	Ba	5.2×10^{-1}	As	6.9×10^{-4}
	Co	1.4×10^{0}	Cr	5.2×10^{-4}
			Rn-222	3.6×10^{-5}
			U-238	5.5×10^{-5}
Subtotal:		2.3×10^{0}		1.9×10^{-4}
⋮	⋮		⋮	
Receptor Total:		7.1×10^{1}		8.4×10^{-3}

(1) Hypothetical RME Receptor

(2) Significant COCs and their contribution to HI/ILCR

(3) Pathway Total (includes all COCs)

(4) Pathway or Route of Exposure

(5) Receptor HI/ILCR Totals

COC = Contaminant of Concern

HI = Hazard Index

ILCR = Incremental Lifetime Cancer Risk

NA = Not Applicable

[a]Not shown: Off-property farm adult, which is identical under Future Land Use With Federal Ownership scenario (see Table I.11-3).

Current Land Use Scenario

Table I.11-2 summarizes the pathway-specific risks for the Current Land Use receptors. The off-property farm adult receptors have a life-time cancer risk greater than the target range of 10^{-4} to 10^{-6}, primarily due to the inhalation of particulate and, to a lesser extent, the consumption of groundwater from the south plume. Carcinogenic risks for the trespassing child are within the 10^{-4} to 10^{-6} range. The major pathways are dermal exposure to beryllium and external radiation exposure from Cs-137, Th-228, Ra-226, Ra-228, and U-238. The groundskeeper is above the target cancer risk range by roughly 40 percent, primarily due to dermal exposure to soils and to external radiation exposure from Ra-226, Ra-228 and Th-228.

The noncarcinogenic HIs are below the benchmark of 1 for the trespassing child, and are above 1 for the groundskeeper and the off-property resident farm receptors. This is primarily due to the inhalation of particulate containing metals such as cobalt and manganese.

Future Land Use With Federal Ownership Scenario

The risks for receptors under the Future Land Use With Federal Ownership scenario are summarized by pathway in Table I.11-3. The risk results for the off-property receptors are similar to those found in the Current Land Use scenario. Carcinogenic risks are greater than the range of 10^{-4} to 10^{-6} with the major pathways being inhalation of particulate containing chromium, U-234, and U-238 and the ingestion of drinking water, and vegetables and fruit.

Noncarcinogenic HIs exceed 1 for the farm receptors due to inhalation of cobalt and manganese in particulate matter.

The carcinogenic risk and noncarcinogenic HI for the expanded trespasser and trespassing child are within the target ranges.

Future Land Use Without Federal Ownership Scenario

Table I.11-4 summarizes the risks under the Future Land Use Without Federal Ownership scenario. Carcinogenic risks exceed the target level of 10^{-4} to 10^{-6} for the on-property resident farm receptors (adult and child) due to ingestion of farm food products (Aroclors and arsenic), incidental ingestion of soil (arsenic, beryllium, U-234 and Pb-210), dermal contact with soils (beryllium), and external radiation from Ra-228 and Ra-226. The inhalation of particulate

containing U-234 isotopes also gives risks above the 10^{-4} level for all on-property receptors. The ingestion of perched groundwater increases the ILCR for the adult farmer by about 100 percent.

The on-property farm receptors (adult and child) all exceed the HI benchmark of 1, primarily due to inhalation of particulates, ingestion of soil, dermal contact with soil, and ingestion of meat, vegetables, and dairy products grown on the FEMP. The principal COCs are boron, cobalt, mercury, molybdenum, silver, and zinc.

The off-property resident farm receptors (adult and child) have the same risk as for the Future Land Use With Federal Ownership scenario for both the HI and the ILCR.

The elevated HIs for the on-property farm receptors due to inhalation of particulates should be considered conservative. This can be attributed to the use of conservative toxicity factors for cobalt and manganese as well as the conservative nature of the dust resuspension model. In fact, these HIs may be overestimated by a factor of 100. The presence of the Aroclors is due to the very conservative biotransfer factors in the foodchain modeling. See Section I.11.7 for more information.

Target Organ Impacts

An analysis of the major impact on target organs for all receptors whose HIs exceed the benchmark of 1 is presented in Table I.11-5. This analysis was performed for these receptors in order to determine which organs are adversely impacted and to identify the major contributing contaminants. For the contaminant RfDs and RfCs used in the noncarcinogenic health hazard analysis, the EPA IRIS database and HEAST were used as the sources of target organs/critical effects. The target organ impacts and responsible contaminants are summarized below.

For the groundskeeper and off-property farm adult and child receptor, the major target organs are the liver (cobalt) and the central nervous system (manganese).

For the on-property farm adult and child, the major target organs include the liver (cobalt), testis (boron), kidney (mercury and cadmium), skin (arsenic and silver), whole body (antimony), and the central nervous system (manganese).

TABLE I.11-5
ANALYSIS OF MAJOR IMPACTS ON TARGET ORGANS

	Groundskeeper	Off-Property Farm Adult	Off-Property Farm Child	On-Property Farm Adult	On-Property Farm Child
Air	Liver 6.07×10^{-1} Co 6.07×10^{-1} CNS 1.36×10^{-1} Mn 1.36×10^{-1} Fetus 1.70×10^{-2} Ba 1.70×10^{-2}	Liver 8.50×10^{-1} Co 8.50×10^{-1} CNS 1.91×10^{-1} Mn 1.91×10^{-1} Fetus 2.38×10^{-2} Ba 2.38×10^{-2}	Liver 2.38×10^{0} Co 2.38×10^{0} CNS 5.35×10^{-1} Mn 5.35×10^{-1}	Liver 1.65×10^{0} Co 1.65×10^{0} CNS 3.76×10^{-1} Mn 3.76×10^{-1} Fetus 5.23×10^{-2} Ba $5.23\ 10^{-2}$	Liver 4.63×10^{0} Co 4.63×10^{0} CNS 1.05×10^{0} Mn 1.05×10^{0}
Subtotal:	7.61×10^{-1}	1.07×10^{0}	2.98×10^{0}	2.08×10^{0}	5.84×10^{0}
Water	Not Calculated (Pathway Incomplete)	Body 2.09×10^{-5} Sb 2.09×10^{-5}	Body 4.87×10^{-5} Sb 4.87×10^{-5}	Body 8.49×10^{-2} Sb 8.49×10^{-2}	Body 1.98×10^{-1} Sb 1.98×10^{-1}
Subtotal:		2.09×10^{-5}	4.87×10^{-5}	8.49×10^{-2}	1.98×10^{-1}
Soil	CNS 1.38×10^{-1} Mn 1.38×10^{-1} Body 6.49×10^{-2} Sb 6.33×10^{-2} Ni 1.42×10^{-3} Kdny 5.67×10^{-2} Cd 4.26×10^{-2} Hg 1.41×10^{-2} None 2.81×10^{-2} Tl 1.21×10^{-2} Be 8.64×10^{-3} Cr 7.31×10^{-3}	Not Calculated (Pathway Incomplete)	Not Calculated (Pathway Incomplete)	Skin 7.71×10^{-1} As 7.63×10^{-1} Body 5.50×10^{-1} Sb 5.40×10^{-1} None 2.33×10^{-1} Tl 1.19×10^{-1} Testis 1.33×10^{-1} B 1.33×10^{-1} Kdny 2.13×10^{-1} Cd 1.08×10^{-1} Hg 1.05×10^{-1}	Skin 3.91×10^{0} As 3.87×10^{0} Body 1.53×10^{0} Sb 1.49×10^{0} None 7.61×10^{-1} Tl 4.80×10^{-1} Testis 2.79×10^{-1} B 2.79×10^{-1} Kdny 4.30×10^{-1} Cd 2.27×10^{-1} Hg 2.03×10^{-1}
Subtotal:	3.36×10^{-1}			2.41×10^{0}	8.03×10^{0}
Food	Not Calculated (Pathway Incomplete)	Kdny 3.09×10^{-6} U 2.75×10^{-6} Hg 2.73×10^{-7} None 4.05×10^{-7} Tl 3.46×10^{-7}	Kdny 1.52×10^{-5} U 1.43×10^{-5} Hg 5.32×10^{-7} None 1.49×10^{-6} Tl 1.18×10^{-6}	Testis 2.63×10^{0} B 2.63×10^{0} Kdny 9.09×10^{0} Hg 8.45×10^{0} Cd 6.42×10^{-1} Skin 2.28×10^{0} Ag 2.15×10^{0} Blood 2.39×10^{0} Zn 2.39×10^{0}	Testis 2.02×10^{1} B 2.02×10^{1} Kdny 2.10×10^{1} Hg 1.59×10^{1} Cd 5.09×10^{0} Skin 2.22×10^{1} Ag 2.18×10^{1} Blood 1.03×10^{1} Zn 1.03×10^{1} CNS 1.95×10^{0} Mn 1.95×10^{0} Urine 1.48×10^{0} Mo 1.48×10^{0}
Subtotal:		4.37×10^{-6}	2.12×10^{-5}	1.76×10^{1}	7.96×10^{1}
Receptor Total:	1.10×10^{0}	1.07×10^{0}	2.98×10^{0}	2.2×10^{1}	9.36×10^{1}

Body = Whole body
CNS = Central nervous system
Kdny = Kidney
None = None observed

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I.11.3 SUMMARY OF UNCERTAINTIES

The preparation of this Operable Unit 1&2 CRARE employed conservative assumptions and the best scientific and engineering judgement consistent with the EPA guidance expressed in RAGS (EPA 1989l). The risk principles and equations found in the RAWPA were used throughout this analysis. The exposure parameters found in the Operable Unit 2 RI were used in this CRARE. Deviations are summarized in Section I.2.5. Results of the CRARE have identified points of departure from target risk ranges, as discussed in the NCP.

Inhalation of particulates and radon is a principal component of the carcinogenic and noncarcinogenic risks that exceed the target ranges. Another significant contributor is the deposition of dust on crops and the subsequent uptake of COCs into the foodchain by plants. The two major elements of uncertainty in these pathways include the dust emission rate and food consumption parameters. The development of emission factors for air modeling and the use of the modeling results for the subsequent inhalation intake are likely overestimated. This potential overestimate is inherent in the RAWPA emission rate model, which was developed for short-term emissions. After using these models, it appears that some results tend to misrepresent the actual scenario. For example, the assumptions used in the Rapid Assessment Model for particulate emission generation may be inappropriate and may not reflect the true nature of the long term scenarios evaluated in the CRARE.

The critical assumptions in this model are the percentage of vegetative cover, the resuspension rate at different wind speeds, and the surface characteristics of exposed soils. In this CRARE, a vegetative cover of 85 percent was assumed, which is a realistic value. The model is not designed to accurately produce different emission rates with different wind speeds and classes because the algorithm is designed for annual averages. The algorithm's effect on the varying emissions is unknown. A potential source of over-conservatism is the assumption that the uncovered surfaces were relatively smooth and consisted of loose, fine, silty particles.

One hundred percent of the meat and milk and fifty percent of the fruit and vegetables consumed by the on- and off-property farmers were assumed to come from their farms. This assumption is both conservative and unlikely. The nature of the uncertainties associated with the RAWPA and other assumptions for the CRARE are summarized below and in Table I.11-6.

COC Selection. There are no major uncertainties in the selection of COCs for any of the pathways' receptors.

Toxicological Information and Models. The inhalation pathway risks are likely to be overestimated due to the conservatism of the inhalation RfDs and cancer slope factors. It is unlikely that any major exposure pathways have not been evaluated.

Exposure Pathways. It is unlikely that any major exposure pathways have not been evaluated.

Receptor Characterization. Due to the range of receptors selected, it is unlikely that a significant receptor has been left out. It must be noted that the use of a resident farm receptor is more conservative than the use of a residential receptor.

Exposure Point Concentrations. Preliminary calculations have indicated that the fugitive particulate emissions model may be overestimating emissions. The applicability of the model needs to be further investigated and will be addressed in future CRAREs. The surface characteristics of the remediated FEMP need to be more fully characterized. The major uncertainty relating to groundwater modeling is due to source term uncertainty and the quantity of material leaching out of the disposal areas over time. This is also an uncertainty relating to rate of leaching (i.e., partitioning factors) from surface soil materials.

Groundwater Modeling. Current groundwater modeling predicts that the highest cancer risk in this pathway will be associated with COCs leaching from the site-wide soil, which will be addressed by Operable Unit 5. An important consideration is that the accuracy of the groundwater modeling depends on the representativeness of the geochemical, surface-water and vadose-zone transport modeling. These processes are affected by many parameters, some of which vary by orders of magnitude across the site. The use of a numerical, multi-dimensional vadose-zone model, rather than the analytical ODAST model, is also being evaluated. These developments should reduce the uncertainty associated with the geochemical and vadose-zone simulations, and may cause major changes in the groundwater modeling results.

TABLE I.11-6

SUMMARY OF UNCERTAINTIES, ACTIONS FOR REDUCTION

Uncertainty Problem	Specification of Problem	Direction and Extent of Uncertainty	Effects on the Reported Risks	Actions for Reduction of Uncertainty
COC Selection				
1. Species of Contaminants	Not all COCs have been identified.	Low order of uncertainty. Probably localized in small areas: OU 3 and 4 trench	Probably underestimates risks by a factor less than 10.	Specific review of existing histories to determine if investigation of these three areas is warranted.
2. Quality of COC Information	Not all quantities are known and validated in various media.	Moderate order of uncertainty involving material volumes. Specific areas to address would include pipe/trench between OU4 and OU3 and OU3 soils.	Varied. Can overestimate or underestimate risk by more than 1 order of magnitude.	Focus calculations on known waste volumes and predict by facility capacities.
Toxicological Information and Models	Extrapolation of data missing RfDs or slope factors.	Underestimates COCs not quantified.	Varied. Can range from less than a factor of 10 to 1 order of magnitude.	Contact EPA ECAO to derive constants.
	Conservative derivation of slope factors and RfDs.	Overestimates risks for all COCs.	May overestimate risk by 2 to 3 orders of magnitude.	Re-evaluate derivations and conservative assumptions
	Linear dose-response modeling.	Overestimates risks for some contaminants.	May overestimate risks by several orders of magnitude.	Carefully evaluate toxicity data and risk results.
Exposure Pathways	Improbable pathways to receptors; lack of institutional controls after 70 years.	Depending on the land use, the receptors may represent an overestimate.	Moderate. Possibly 1 order of magnitude.	Establish end land use and guiding receptor for FEMP with EPA.
Receptor Characterization				
1. Expanded Trespasser	Exposure of 110 days per year may be excessive.	Mild overestimate for drinking water exposures by using a maximum concentration and swimming in Paddys Run, etc.	Overestimates by less than a factor of 3.	Propose to eliminate unlikely pathways.
2. Resident Farm Receptors	Assumption that 50 percent of fruit and vegetables and 100 percent of meat and milk is derived from the farm.	Overestimate.	Possibly a factor of 3.	Consider a reduction of consumption.
	Estimation of exposure parameters.	In general, the exposure parameters are mild overestimates.	Mild. Less than 1 order of magnitude.	Better characterization of living habits of receptors.

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TABLE I.11-6
(Continued)

Uncertainty Problem	Specification of Problem	Direction and Extent of Uncertainty	Effects on the Reported Risks	Actions for Reduction of Uncertainty
Exposure Point Concentration				
1. Air Concentrations	Surface soil concentrations.	Unknown due to lack of data.	Unknown.	Collect more data concerning surface soils and remediated soils.
	Dust emission rate relating to vegetative cover and particle size.	Vegetative cover assumptions may cause underestimate, particularly relating to farming activities. May be offset if particle size distribution shows low potential for particulate generation.	Mild. Less than 1 order of magnitude.	Gather site-specific soil particle size distribution data.
	Temporal correlation between particulate generation and dispersion not accounted for.	Overestimate of air particulate expansion.	Probably moderate. 1 order of magnitude or less.	Perform refined air modeling for particulates using short-term generation rates.
2. Groundwater Concentration	Migration rate.	Overestimate due to selecting small K_d values. This affects both concentrations and time of peak.	Moderate. 1 to 2 orders of magnitude.	Perform studies of site-specific K_d relating to specific media.
	Leachate concentrations.	Overestimate due to conservative assumptions, also availability of contaminants.	Moderate. 1 to 2 orders of magnitude.	Perform studies of leaching of contaminants from remediated and unremediated materials.
	Source term.	Direction is unknown due to the overall uncertainty in the extent of contamination. Could be an underestimate.	Moderate. Could vary both plus and minus 1 order of magnitude.	Improve characterization.
3. Farm Product Concentrations	Toxicity of COC on Farm Product.	Could be an overestimate.	Unknown.	Specific review of data on COC toxicity on farm products.
				Risks are currently calculated assuming crops are irrigated with contaminated groundwater. In actuality, studies of the area indicate that rainwater is the primary source of crop water.

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I.12.0 CONCLUSIONS AND RECOMMENDATIONS

I.12.1 OPERABLE UNIT CONTRIBUTIONS TO RISK

Each operable unit's contribution to site-wide risk is specific to the RME receptor point selected. Since this CRARE reflects the predicted point of maximum impact, each RME receptor is proximate to the most influential source. The removal off-property of Operable Unit 1 and 4 wastes, the capping of Operable Unit 2, and the sealing of Operable Unit 3 wastes in vaults will leave no significant source terms for RME receptors. The volume of uncapped remediated soils from Operable Unit 5 is therefore predicted to provide the bulk of residual risk under postremediation conditions.

Operable Unit 1 and 2 Contributions to FEMP Residual Risk

The Operable Unit 2 cap designs, as well as the removal of Operable Unit 1 material off-property, will preclude these sources from contributing significant risk to human health or the environment. These operable units are estimated to contribute less than 0.01 percent of total site risk to any one receptor through the groundwater, surface water, soil ingestion, and dermal contact with soils pathways. Total risk contributions for Operable Units 1 and 2 via the air pathway are 0.12 and 1.20 percent, respectively.

Operable Unit 4 Contributions to FEMP Residual Risk

Operable Unit 4 contributes very little to the carcinogenic and noncarcinogenic risks. The majority of the COCs from Operable Unit 4 will be removed off-site or isolated in the vaults, away from human contact and the environment. Less than 0.83 percent of radionuclide emissions are from Operable Unit 4 under the Future Land Use scenario.

Operable Unit 3 and 5 Contributions to FEMP Residual Risk

Operable Unit 5 contamination is associated with almost all of the residual risk after FEMP remediation. Under the Current Land Use scenario, greater than 99 percent of radionuclide emissions are from Operable Unit 5 (the former production area soils and the remaining FEMP surface soil). The soil beneath the former production area accounts for greater than 99 percent

TABLE I.12-1

OPERABLE UNIT CONTRIBUTIONS TO RISK

Contributions to Radiological Risk: Air/Radiation Exposure

	Contribution (%)				
RME Receptor	**OU1**	**OU2**	**OU3**	**OU4**	**OU5**
Trespassers	0.12	0.22	<0.01	0.12	99.53
Groundskeeper	0.12	0.22	<0.01	0.12	99.53
Off-Property Resident (Adult)	0.12	0.22	<0.01	0.12	99.53
On-Property Resident (Adult)	0.08	1.20	<0.01	0.83	97.88

Contributions to Radiological and Chemical Risk: COC Mass Loading in Ground/Surface Water

	Contribution (%)				
	OU1	**OU2**	**OU3**	**OU4**	**OU5**
COC Mass/Total Mass (mg/l)	<0.01	<0.01	<0.01	<0.01	100

Contributions to Carcinogenic Risk: Ingestion of and Dermal Contact with Soil

	Contribution (%)				
RME Receptor	**OU1**	**OU2**	**OU3**	**OU4**	**OU5**
Trespassers	<0.01	<0.01	<0.01	<0.01	>99.00
Groundskeeper	<0.01	<0.01	<0.01	<0.01	>99.00
On-Property Resident (Adult)	<0.01	<0.01	<0.01	<0.01	>99.00

of the off-property resident risk. It also accounts for about greater than 99 percent of the on-property groundskeeper and trespasser risk associated with direct inhalation of radionuclides.

Under the two Future Land Use scenarios, atmospheric emissions from Operable Unit 5 result in the largest contributions to inhalation pathway cancer risks. The majority of the radionuclide emissions are from Operable Unit 5 areas, indicating that this operable unit is the major contributor to the inhalation pathway risks. The soil beneath the former production area accounts for greater than 99 percent of the cancer risk for the on-property resident, off-property resident, and expanded trespasser. Surface soil from the remainder of the FEMP accounts for the remaining risks.

I.12.2 CONCLUSIONS

Scenarios

Only the trespassing child and expanded trespasser receptors meet both the carcinogenic and noncarcinogenic health risk criteria for the Current Land Use and the Future Land Use With Federal Ownership scenarios. None of the receptors in the Future Land Use Without Federal Ownership scenario meet both risk criteria.

COCs

The detailed risk analysis indicates that the major radionuclides of concern are U-238, U-234, Tc−99, Th-228, Rn-222, Ra-228, and Pb-210. The principal contributors to the chemical carcinogenic risk are arsenic, beryllium, chromium, and the PCBs. The principal contributors to the noncarcinogenic HI are antimony, arsenic, boron, cobalt, manganese, mercury, molybdenum, silver, and zinc.

Remedial Action

For the RME receptors evaluated, most of the residual risk is contributed by the Operable Unit 5 soils. The conclusion reached by applying the CRARE process is that the FEMP would appear to be unsuitable as a family farm even after remediation is complete. Also, to meet the ILCR and HI criteria for off-property farm residents, additional information specific to the Operable 5 Feasibility Study will be needed.

I.12.3 RECOMMENDATIONS

Because the majority of the FEMP residual risk is associated with Operable Unit 5 soils, future CRAREs should focus on refining and completing information on this unit. For example, more accurate modeling of COC concentrations, less than the cleanup levels for the Operable Unit 5 soils, would decrease risk. Additional recommended measures to reduce uncertainty in the CRARE need to be evaluated in the Operable Unit 5 FS. Other specific recommendations would include:

- Conduct bench-scale testing of how remediated soil conditions will change, for modeling purposes.
- Conduct investigations into the physical characteristics of the remediated soils and develop an appropriate fugitive particulate emission model for long-term risk analysis.
- Conduct risk mapping to show isopleths describing the areas where the ILCR is less than 10^{-4} and the HI is less than 1. As shown in this CRARE, the risk of a modeled receptor is a function of several factors, including its location and the cumulative source terms of the area under study. Consequently, a bias is introduced by using only one receptor point to predict on-property farm resident risk. Risk mapping will facilitate the free-release of areas for development and avoid relying on a single point for health risk modeling.

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COMPREHENSIVE RESPONSE ACTION RISK EVALUATION FOR OPERABLE UNITS 1 AND 2

ATTACHMENTS

I.I INPUT FILES FOR ODAST MODEL

I.II U-238 MASS LOADINGS TO SWIFT III MODEL

I.III AIR FATE AND TRANSPORT MODELING INPUT AND OUTPUT

I.IV EXPOSURE CALCULATIONS

I.V TECHNICAL REPORTS

APRIL 29, 1994

ATTACHMENT I.I

INPUT FILES FOR ODAST MODEL

```
CRARE 1&2 U-238 INPUT FILE : S.C. CHEN 3/30/1994
                1  1.00E+00  1000.0  10.0  4.25E-13
75 1 2 3 4 5 6 7 8 9
10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29
30 31 32 33 34 35 36 37 38 39
40 41 42 43 44 45 46 47 48 49
50 51 52 53 54 55 56 57 58 59
60 61 62 63 64 65 66 67 68 69
70 71 72 73 74 75
1
swtru.dat
5.06E-04
1


EAST VAULT FOR CRU-3
   1   0.5118     .039   .02642     .340      .09    45.00      .39
SOUTHEAST DISPOSAL CELL FOR OU2 WASTES (INTERIOR)
   2   2.0300     .039   .02642     .340      .09    45.00      .39
CRU-4 : SILO 1 2 & 3 - CRU-4 RESIDUAL AREA
   3   6.0000     .039   .02642     .340      .09    45.00      .39
CRU-4 : SILO 1 2 & 3 - CRU-4 PERCHED WATER AREA
   4   6.0000     .039   .02642     .340      .09    45.00      .39
CRU-3 : WEST OF PLANT AREA
   5   7.5000     .039   .02642     .340      .09    45.00      .39
CRU-3 : WEST OF PLANT AREA PERCHED WATER
   6   7.5000     .039   .02642     .340      .09    45.00      .39
CRU-3 : EAST OF PLANT AREA
   7   7.5000     .039   .02642     .340      .09    45.00      .39
CRU-3 : EAST OF PLANT AREA PERCHED WATER
   8   7.5000     .039   .02642     .340      .09    45.00      .39
CRU-3 : PLANT 2/3 AREA
   9   0.7500     .039   .02642     .340      .09    45.00      .39
CRU-3 : PLANT 2/3 AREA PERCHED WATER
  10   0.7500     .039   .02642     .340      .09    45.00      .39
CRU-3 : PLANT 6 AREA
  11   0.7500     .039   .02642     .340      .09    45.00      .39
CRU-3 : PLANT 6 AREA PERCHED WATER
  12   0.7500     .039   .02642     .340      .09    45.00      .39
CRU-3 : PLANT 9 AREA
  13   0.7500     .039   .02642     .340      .09    45.00      .39
CRU-3 : PLANT 9 AREA PERCHED WATER
  14   0.7500     .039   .02642     .340      .09    45.00      .39
CRU-3 : OTHER MAIN PLANT AREA
  15   7.5000     .039   .02642     .340      .09    45.00      .39
CRU-3 : OTHER MAIN PLANT AREA PERCHED WATER
  16   7.5000     .039   .02642     .340      .09    45.00      .39
OTHER PERCHED WATER
  17   7.5000     .039   .02642     .340      .09    45.00      .39
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
  18    7.5000    0.0390   0.0186    0.3400    0.0900   45.0000    0.3900
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
  19    0.9100    0.0390   0.0186    0.3400    0.0900   45.0000    0.3900
Grid Block  28  65  Z2
  20 9.61  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Grid Block  29  60  Z2
  21 9.61  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Grid Block  29  62  Z2
  22 9.61  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Grid Block  30  58  Z2
  23 9.61  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Grid Block  30  61  Z2
  24 9.61  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Grid Block  28  59  Z3
  25 9.61  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Grid Block  29  58  Z3
  26 9.61  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Grid Block  29  59  Z3
```

27 9.61 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 29 63 Z3
28 9.61 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 29 67 Z4
29 1.28 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 30 63 Z4
30 1.28 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 30 64 Z4
31 1.28 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 30 67 Z4
32 1.28 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 30 59 Z5
33 3.73 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 30 60 Z5
34 3.73 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 31 58 Z5
35 3.73 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 31 59 Z6
36 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 31 60 Z6
37 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 32 63 Z6
38 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 33 59 Z6
39 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 33 60 Z6
40 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 33 61 Z6
41 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 33 62 Z6
42 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 33 63 Z6
43 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 34 60 Z6
44 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 34 61 Z6
45 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 34 62 Z6
46 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 35 61 Z6
47 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 31 61 Z7
48 1.93 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 31 62 Z7
49 1.93 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 31 63 Z7
50 1.93 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 31 64 Z8
51 2.71 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 31 65 Z8
52 2.71 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 32 59 Z8
53 2.71 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 32 60 Z8
54 2.71 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 32 61 Z8
55 2.71 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 32 62 Z8
56 2.71 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Grid Block 32 64 Z8
57 2.71 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Perched Water 29 67 Z4
58 1.28 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Perched Water 32 63 Z6
59 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Perched Water 33 59 Z6
60 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39
Perched Water 33 60 Z6
61 1.22 0.039 3.969E-04 0.41 0.09 4.507E+01 0.39

```
Perched Water 33  61  Z6
  62 1.22  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 33  62  Z6
  63 1.22  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 33  63  Z6
  64 1.22  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 34  60  Z6
  65 1.22  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 34  61  Z6
  66 1.22  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 34  62  Z6
  67 1.22  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 35  61  Z6
  68 1.22  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 31  64  Z8
  69 2.71  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 31  65  Z8
  70 2.71  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 32  59  Z8
  71 2.71  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 32  60  Z8
  72 2.71  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 32  61  Z8
  73 2.71  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 32  62  Z8
  74 2.71  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39
Perched Water 32  64  Z8
  75 2.71  0.039  3.969E-04  0.41     0.09  4.507E+01  0.39


1
EAST VAULT FOR CRU-3 - BLOCKS FROM UCRARE.WK3 P:\ENGDATA\GEOT\KEEP\CR12NEW\U-238
  1   1       0.  0
  1 2.635E+12 3.289E-03 1163.0 11.75  U-238
 26
 61   63   62   62
 60   63   63   63
 58   64   64   64
 57   64   65   65
 58   65   66   66
 59   65   67   67
 59   66   68   68
 60   67   69   69
 60   67   70   70
 61   68   71   71
 61   68   72   72
 62   69   73   73
 63   70   74   74
 63   70   75   75
 64   71   76   76
 64   71   77   77
 65   72   78   78
 65   72   79   79
 66   73   80   80
 67   74   81   81
 67   74   82   82
 67   74   83   83
 68   75   84   84
 68   75   85   85
 69   76   86   86
 70   71   87   87
  0
SOUTH EAST DISPOSAL CELL FOR OU2 WASTES (INTERIOR)- UCRARE.WK3 ON P:\ENGDATA\GEOT\KEEP\CRARE
  2   2       0.0   0
  1 0.000E+00 0.0000E+00 1001.0 11.75    U-238
  7
 53   53   51   51
 51   53   52   52
 49   54   53   53
```

```
 50  54  54  54
 50  55  55  55
 51  54  56  56
 51  52  57  57
  0
CRU-4 : SILOS 1 2 & 3 - CRU-4 RESIDUAL AREA
  3   3      0.0  0
  1 1.083E+07  1.50E-00 63.82 11.75    U-238
  4
 36  37  87  87
 35  37  85  86
 34  36  84  84
 34  35  83  83
  0
CRU-4 : SILOS 1 2 & 3 - CRU-4 PERCHED WATER
  4   4      0.0  1    0.5
  1 3.559E+04  2.01E-01 63.82 11.75    U-238
  4
 36  37  87  87
 35  37  85  86
 34  36  84  84
 34  35  83  83
  0
CRU-3 : WEST OF PLANT AREA
  5   5      0.0  0
  1 8.742E+08 5.563E-01  1.163E+03 11.75E+00 U-238
  5
 41  41  88  88
 40  42  87  87
 39  43  86  86
 39  42  85  85
 41  42  84  84
  0
CRU-3 : WEST OF PLANT AREA PERCHED WATER
  6   6      0.0  1   0.5
  1 5.339E+04 2.010E-01  1.163E+03 11.75E+00 U-238
  5
 41  41  88  88
 40  42  87  87
 39  43  86  86
 39  42  85  85
 41  42  84  84
  0
CRU-3 : EAST OF PLANT AREA
  7   7      0.0  0
  1 4.080E+08 5.563E-01  1.163E+03 11.75E+00 U-238
  3
 65  65  64  64
 64  67  63  63
 65  66  62  62
  0
CRU-3 : EAST OF PLANT AREA PERCHED WATER
  8   8      0.0  1    0.5
  1 2.492E+04 2.010E-01  1.163E+03 11.75E+00 U-238
  3
 65  65  64  64
 64  67  63  63
 65  66  62  62
  0
CRU-3 : PLANT 2/3 AREA
  9   9      0.0  0
  1 9.325E+08 5.563E-01  7.953E+01 11.75E+00 U-238
  1
 47  50  76  79
  0
CRU-3 : PLANT 2/3 AREA PERCHED WATER
 10  10      0.0  1    0.5
  1 5.695E+04 2.010E-01  7.953E+01 11.75E+00 U-238
  1
```

```
 47  50  76  79
  0
CRU-3 : PLANT 6 AREA
 11  11      0.0  0
  1 4.662E+08 5.563E-01  7.953E+01 11.75E+00 U-238
  3
 57  58  70  72
 58  58  73  73
 59  59  72  72
  0
CRU-3 : PLANT 6 AREA PERCHED WATER
 12  12      0.0  1    0.5
  1 2.847E+04 2.010E-01  7.953E+01 11.75E+00 U-238
  3
 57  58  70  72
 58  58  73  73
 59  59  72  72
  0
CRU-3 : PLANT 9 AREA
 13  13      0.0  0
  1 4.662E+08 5.563E-01  7.953E+01 11.75E+00 U-238
  3
 58  60  74  75
 57  57  75  75
 58  58  76  76
  0
CRU-3 : PLANT 9 AREA PERCHED WATER
 14  14      0.0  1  0.5
  1 2.8472e+04 2.010E-01  7.953E+01 11.75E+00 U-238
  3
 58  60  74  75
 57  57  75  75
 58  58  76  76
  0
CRU-3 : OTHER MAIN PLANT BUILDINGS
 15  15      0.0  0
  1 4.403E+09 2.553E-02  1.163E+03 11.75E+00 U-238
 27
 52  54  89  90
 51  56  66  88
 57  58  86  87
 59  60  86  86
 57  62  84  85
 57  63  77  83
 64  65  79  83
 64  64  78  78
 59  63  76  76
 74  75  74  75
 59  61  73  73
 60  61  72  72
 59  60  70  71
 57  58  68  69
 57  57  65  67
 54  56  64  65
 50  50  87  88
 49  50  80  86
 47  48  81  83
 47  48  80  80
 45  46  76  80
 44  50  70  75
 48  50  68  69
 49  50  67  67
 44  44  86  88
 43  43  71  76
 42  42  72  74
  0
CRU-3 : OTHER MAIN PLANT BUILDINGS PERCHED WATER
 16  16      0.0  1  0.5
  1 1.128E+06 2.010E-01  1.163E+03 11.75E+00 U-238
```

```
 27
 52  54  89  90
 51  56  66  88
 57  58  86  87
 59  60  86  86
 57  62  84  85
 57  63  77  83
 64  65  79  83
 64  64  78  78
 59  63  76  76
 74  75  74  75
 59  61  73  73
 60  61  72  72
 59  60  70  71
 57  58  68  69
 57  57  65  67
 54  56  64  65
 50  50  87  88
 49  50  80  86
 47  48  81  83
 47  48  80  80
 45  46  76  80
 44  50  70  75
 48  50  68  69
 49  50  67  67
 44  44  86  88
 43  43  71  76
 42  42  72  74
 0
OTHER PERCHED WATER
 17  17      0.0 1    0.5
 1 5.612e+06 0.201e+00  1.163E+03 11.75E+00 U-238
 3
 20  35  56  102
 35  64  56  69
 20  64  94  102
 0
SURFACE SOIL CELLS WITHOUT CAP
  18 18    0.0    0
  1  2.257E+10    7.4404E-01   1.257E+03 11.75  U-238
  7
 36  40  96  98
 36  37  90  90
 39  46  90  90
 44  46  93  94
 45  46  95  97
 44  44  96  97
 43  43  97  97
 0
SURFACE SOIL CELLS WITH CAP
 19  19    0.0    0
  1  6.188E+09   7.4404E-01    1.257E+03  11.75   U-238
  6
 39  39  91  92
 41  41  92  95
 42  42  92  92
 42  42  94  94
 45  45  91  92
 43  43  93  93
 0
28,65 Z2
    20       20       0.0        0
     1  4.930E+07  8.270E-02  1.001E+03  3.660E+01   U-238
     0
     1
    28       65
29,60 Z2
    21       21       0.0        0
     1  1.390E+06  3.140E-02  1.001E+03  3.660E+01   U-238
```

```
    0
    1
    29      60
29,62 Z2
    22      22      0.0       0
    1  4.510E+07  8.270E-02  1.001E+03  3.660E+01   U-238
    0
    1
    29      62
30,58 Z2
    23      23      0.0       0
    1  3.290E+07  8.270E-02  1.001E+03  3.660E+01   U-238
    0
    1
    30      58
30,61 Z2
    24      24      0.0       0
    1  8.520E+06  8.267E-02  1.001E+03  3.660E+01   U-238
    0
    1
    30      61
28,59 Z3
    25      25      0.0       0
    1  6.020E+07  4.310E-02  1.001E+03  4.001E+01   U-238
    0
    1
    28      59
29,58 Z3
    26      26      0.0       0
    1  1.150E+08  8.267E-02  1.001E+03  4.001E+01   U-238
    0
    1
    29      58
29,59 Z3
    27      27      0.0       0
    1  2.180E+08  8.267E-02  1.001E+03  4.001E+01   U-238
    0
    1
    29      59
29,63 Z3
    28      28      0.0       0
    1  2.030E+08  8.267E-02  1.001E+03  4.001E+01   U-238
    0
    1
    29      63
29,67 Z4
    29      29      0.0       0
    1  8.540E+06  8.267E-02  1.001E+03  5.096E+01   U-238
    0
    1
    29      67
30,63 Z4
    30      30      0.0       0
    1  2.440E+07  8.267E-02  1.001E+03  5.096E+01   U-238
    0
    1
    30      63
30,64 Z4
    31      31      0.0       0
    1  1.460E+07  8.267E-02  1.001E+03  5.096E+01   U-238
    0
    1
    30      64
30,67 Z4
    32      32      0.0       0
    1  7.300E+06  8.267E-02  1.001E+03  5.096E+01   U-238
    0
    1
    30      67
```

```
30,59 Z5
   33      33      0.0       0
    1 8.900E+07 7.260E-02 1.001E+03 4.415E+01  U-238
    0
    1
   30      59
30,60 Z5
   34      34      0.0       0
    1 6.870E+07 5.700E-02 1.001E+03 4.415E+01  U-238
    0
    1
   30      60
31,58 Z5
   35      35      0.0       0
    1 4.520E+07 6.360E-02 1.001E+03 4.415E+01  U-238
    0
    1
   31      58
31,59 Z6
   36      36      0.0       0
    1 1.960E+07 1.750E+01 1.001E+03 6.429E+01  U-238
    0
    1
   31      59
31,60 Z6
   37      37      0.0       0
    1 2.060E+07 1.750E+01 1.001E+03 6.429E+01  U-238
    0
    1
   31      60
32,63 Z6
   38      38      0.0       0
    1 3.630E+07 1.750E+01 1.001E+03 6.429E+01  U-238
    0
    1
   32      63
33,59 Z6
   39      39      0.0       0
    1 1.130E+07 1.750E+01 1.001E+03 6.429E+01  U-238
    0
    1
   33      59
33,60 Z6
   40      40      0.0       0
    1 9.950E+06 1.750E+01 1.001E+03 6.429E+01  U-238
    0
    1
   33      60
33,61 Z6
   41      41      0.0       0
    1 1.630E+07 1.750E+01 1.001E+03 6.429E+01  U-238
    0
    1
   33      61
33,62 Z6
   42      42      0.0       0
    1 1.980E+08 1.750E+01 1.001E+03 6.429E+01  U-238
    0
    1
   33      62
33,63 Z6
   43      43      0.0       0
    1 1.370E+08 1.750E+01 1.001E+03 6.429E+01  U-238
    0
    1
   33      63
34,60 Z6
   44      44      0.0       0
    1 1.550E+07 1.750E+01 1.001E+03 6.429E+01  U-238
```

```
     0
     1
    34       60
34,61 Z6
    45       45      0.0       0
     1  5.090E+07  1.750E+01  1.001E+03  6.429E+01   U-238
     0
     1
    34       61
34,62 Z6
    46       46      0.0       0
     1  5.160E+09  1.750E+01  1.001E+03  6.429E+01   U-238
     0
     1
    34       62
35,61 Z6
    47       47      0.0       0
     1  5.160E+09  1.750E+01  1.001E+03  6.429E+01   U-238
     0
     1
    35       61
31,61 Z7
    48       48      0.0       0
     1  4.390E+07  8.270E-02  1.001E+03  4.769E+01   U-238
     0
     1
    31       61
31,62 Z7
    49       49      0.0       0
     1  4.750E+07  8.270E-02  1.001E+03  4.769E+01   U-238
     0
     1
    31       62
31,63 Z7
    50       50      0.0       0
     1  4.260E+07  8.270E-02  1.001E+03  4.769E+01   U-238
     0
     1
    31       63
31,64 Z8
    51       51      0.0       0
     1  1.270E+08  8.270E-02  1.001E+03  4.550E+01   U-238
     0
     1
    31       64
31,65 Z8
    52       52      0.0       0
     1  6.940E+07  8.270E-02  1.001E+03  4.550E+01   U-238
     0
     1
    31       65
32,59 Z8
    53       53      0.0       0
     1  3.940E+07  3.770E-02  1.001E+03  4.550E+01   U-238
     0
     1
    32       59
32,60 Z8
    54       54      0.0       0
     1  9.500E+07  8.270E-02  1.001E+03  4.550E+01   U-238
     0
     1
    32       60
32,61 Z8
    55       55      0.0       0
     1  6.230E+07  5.450E-02  1.001E+03  4.550E+01   U-238
     0
     1
    32       61
```

```
32,62 Z8
   56      56      0.0       0
    1 2.280E+08 1.610E-02 1.001E+03 4.550E+01  U-238
    0
    1
   32      62
32,64 Z8
   57      57      0.0       0
    1 3.850E+07 4.360E-02 1.001E+03 4.550E+01  U-238
    0
    1
   32      64
29,67 Z4  P
   58      58      0.0       1     0.629
    1 2.192E+06 7.649E-01 1.001E+03 5.096E+01  U-238
    0
    1
   29      67
32,63 Z6  P
   59      59      0.0       1     0.679
    1 2.192E+06 7.649E-01 1.001E+03 6.429E+01  U-238
    0
    1
   32      63
33,59 Z6  P
   60      60      0.0       1     0.554
    1 2.192E+06 7.649E-01 1.001E+03 6.429E+01  U-238
    0
    1
   33      59
33,60 Z6  P
   61      61      0.0       1     0.535
    1 2.192E+06 7.649E-01 1.001E+03 6.429E+01  U-238
    0
    1
   33      60
33,61 Z6  P
   62      62      0.0       1     0.579
    1 2.192E+06 7.649E-01 1.001E+03 6.429E+01  U-238
    0
    1
   33      61
33,62 Z6  P
   63      63      0.0       1     0.609
    1 2.192E+06 7.649E-01 1.001E+03 6.429E+01  U-238
    0
    1
   33      62
33,63 Z6  P
   64      64      0.0       1     0.542
    1 2.192E+06 7.649E-01 1.001E+03 6.429E+01  U-238
    0
    1
   33      63
34,60 Z6  P
   65      65      0.0       1     0.470
    1 2.192E+06 7.649E-01 1.001E+03 6.429E+01  U-238
    0
    1
   34      60
34,61 Z6  P
   66      66      0.0       1     0.565
    1 2.192E+06 7.649E-01 1.001E+03 6.429E+01  U-238
    0
    1
   34      61
34,62 Z6  P
   67      67      0.0       1     0.574
    1 2.192E+06 7.649E-01 1.001E+03 6.429E+01  U-238
```

```
    0
    1
    34      62
35,61 Z6  P
    68      68      0.0       1     0.508
    1  2.192E+06  7.649E-01  1.001E+03  6.429E+01   U-238
    0
    1
    35      61
31,64 Z8  P
    69      69      0.0       1     0.955
    1  2.192E+06  7.649E-01  1.001E+03  4.550E+01   U-238
    0
    1
    31      64
31,65 Z8  P
    70      70      0.0       1     0.856
    1  2.192E+06  7.649E-01  1.001E+03  4.550E+01   U-238
    0
    1
    31      65
32,59 Z8  P
    71      71      0.0       1     0.775
    1  2.192E+06  7.649E-01  1.001E+03  4.550E+01   U-238
    0
    1
    32      59
32,60 Z8  P
    72      72      0.0       1     0.676
    1  2.192E+06  7.649E-01  1.001E+03  4.550E+01   U-238
    0
    1
    32      60
32,61 Z8  P
    73      73      0.0       1     0.699
    1  2.192E+06  7.649E-01  1.001E+03  4.550E+01   U-238
    0
    1
    32      61
32,62 Z8  P
    74      74      0.0       1     0.732
    1  2.192E+06  7.649E-01  1.001E+03  4.550E+01   U-238
    0
    1
    32      62
32,64 Z8  P
    75      75      0.0       1     0.593
    1  2.192E+06  7.649E-01  1.001E+03  4.550E+01   U-238
    0
    1
    32      64
```

```
TC-99 crare OU1/2 run #1  F:\ENGDATA\GEOT\KEEP\CR12NEW\TC-99\SHEET.IN
1 1.0E+09 1000. 10. 8.916E-9
7 1 2 3 4 5 6 7
1
swtr.new
1.59E-08
1


EAST VAULT FOR CRU-3 - P:\ENGDATA\GEOT\KEEP\CR12NEW\TC-99\HELPAREA.DAT
   1   0.5118     .039   .02642     .340      .09    45.00      .39
CRU-2 : SOLID WASTE LANDFILL - IN-SITU CONTAINMENT WITH TYPE B CAP
   2   1.1400     .039   .0053858   .410      .09    45.00      .39
CRU-3 : WEST OF PLANT AREA
   3   7.5000     .039   .02642     .340      .09    45.00      .39
CRU-3 : EAST OF PLANT AREA
   4   7.5000     .039   .02642     .340      .09    45.00      .39
CRU-3 : MAIN PLANT BUILDINGS
   5   7.5000     .039   .02642     .340      .09    45.00      .39
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
   6   7.5000    0.0390   0.0186   0.3400   0.0900  45.0000   0.3900
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
   7   0.9100    0.0390   0.0186   0.3400   0.0900  45.0000   0.3900


1
EAST VAULT FOR CRU-3 : P:\ENGDATA\GEOT\KEEP\CR12NEW\TC-99\WASTAREA.DAT
   1   1       0.  0
   1 2.615e+04 1.055e-03 1.75    1.80  TC-99
  26
  61  63  62  62
  60  63  63  63
  58  64  64  64
  57  64  65  65
  58  65  66  66
  59  65  67  67
  59  66  68  68
  60  67  69  69
  60  67  70  70
  61  68  71  71
  61  68  72  72
  62  69  73  73
  63  70  74  74
  63  70  75  75
  64  71  76  76
  64  71  77  77
  65  72  78  78
  65  72  79  79
  66  73  80  80
  67  74  81  81
  67  74  82  82
  67  74  83  83
  68  75  84  84
  68  75  85  85
  69  76  86  86
  70  71  87  87
   0
CRU-2 : SOLID WASTE LANDFILL - IN-SITU CONTAINMENT WITH TYPE B CAP
   2   2       0.0   0
   1 1.524E+07 1.760E-06 1.544 2.996    TC-99
   1
  50  51  91  92
   0
CRU-3 : WEST OF PLANT AREA
   3   3       0.0   0
   1 5.107E+03 1.055E-03  1.75      1.80      TC-99
   5
  41  41  88  88
  40  42  87  87
```

```
 39  43  86  86
 39  42  85  85
 41  42  84  84
 0
CRU-3 : EAST OF PLANT AREA
 4   4     0.0  0
 1 2.383E+03 1.055E-03  1.75    1.80     TC-99
 3
 65  65  64  64
 64  67  63  63
 65  66  62  62
 0
CRU-3 :  MAIN PLANT BUILDINGS
 5   5     0.0  0
 1 1.818E+05 1.055E-03  1.75    1.80     TC-99
 17
 39  52  62  65
 44  57  66  83
 42  43  69  79
 41  41  70  78
 40  40  70  76
 39  39  71  75
 38  38  72  73
 53  56  65  65
 53  53  62  64
 58  59  69  87
 60  61  72  86
 62  63  75  84
 64  65  78  83
 66  66  80  82
 46  57  84  87
 48  56  88  89
 50  54  90  90
 0
SURFACE SOIL CELLS WITHOUT CAP
 6   6    0.0    0
 1  6.447E+04    4.3370E-03   1.75   1.8   TC-99
 7
 36  40  96  98
 36  37  90  90
 39  46  90  90
 44  46  93  94
 45  46  95  97
 44  44  96  97
 43  43  97  97
 0
SURFACE SOIL CELLS WITH CAP
 7   7    0.0    0
 1  1.773E+04    4.3370e-03   1.75   1.8   TC-99
 6
 39  39  91  92
 41  41  92  95
 42  42  92  92
 42  42  94  94
 45  45  91  92
 43  43  93  93
 0
```

```
CRARE 1&2 AR-1221 INPUT FILE BY S.C. CHEN ON 4/05/1994
1  1.00E+09  1000.0  10.0  0.00E-00
6 1 2 3 4 5 6
1
swtr.ou1
1.00E-06
1


EAST VAULT FOR CRU-3: P:\ENGDATA\GEOT\KEEP\CR12NEW\AR1221\HELPAREA.DAT
   1   0.5118     .039   .02642     .340      .09    45.00      .39
CRU-3 : PLANT 2/3 AREA
   2   0.7500     .039   .02642     .340      .09    45.00      .39
CRU-3 : PLANT 9 AREA
   3   0.7500     .039   .02642     .340      .09    45.00      .39
CRU-3 : OTHER MAIN PLANT AREA
   4   7.5000     .039   .02642     .340      .09    45.00      .39
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
   5   7.5000    0.0390   0.0186   0.3400   0.0900  45.0000   0.3900
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
   6   0.9100    0.0390   0.0186   0.3400   0.0900  45.0000   0.3900


1
EAST VAULT FOR CRU-3 & CRU-4 P:\ENGDATA\GEOT\KEEP\CR12NEW\AR1221
   1   1       0.  0
   1 1.322E+07 8.112E-02 1.50E+03 1.16E+03  AR-1221
  26
  61  63  62  62
  60  63  63  63
  58  64  64  64
  57  64  65  65
  58  65  66  66
  59  65  67  67
  59  66  68  68
  60  67  69  69
  60  67  70  70
  61  68  71  71
  61  68  72  72
  62  69  73  73
  63  70  74  74
  63  70  75  75
  64  71  76  76
  64  71  77  77
  65  72  78  78
  65  72  79  79
  66  73  80  80
  67  74  81  81
  67  74  82  82
  67  74  83  83
  68  75  84  84
  68  75  85  85
  69  76  86  86
  70  71  87  87
   0
CRU-3 : PLANT 2/3 AREA
   2   2       0.0  0
   1 2.200E+08 1.222E-02  1.50E+03 1.16E+03  AR-1221
   1
  47  50  76  79
   0
CRU-3 : PLANT 9 AREA
   3   3       0.0  0
   1 1.163E+07 1.292E-03  1.50E+03 1.16E+03  AR-1221
   3
  58  60  74  75
  57  57  75  75
  58  58  76  76
   0
```

```
CRU-3 : OTHER MAIN PLANT BUILDINGS
  4   4      0.0  0
  1 2.701E+08 6.880E-04  1.50E+03 1.16E+03  AR-1221
 27
 52  54  89  90
 51  56  66  88
 57  58  86  87
 59  60  86  86
 57  62  84  85
 57  63  77  83
 64  65  79  83
 64  64  78  78
 59  63  76  76
 74  75  74  75
 59  61  73  73
 60  61  72  72
 59  60  70  71
 57  58  68  69
 57  57  65  67
 54  56  64  65
 50  50  87  88
 49  50  80  86
 47  48  81  83
 47  48  80  80
 45  46  76  80
 44  50  70  75
 48  50  68  69
 49  50  67  67
 44  44  86  88
 43  43  71  76
 42  42  72  74
  0
SURFACE SOIL CELLS WITHOUT CAP
  5   5    0.0    0
  1  1.000E-41    1.0000E-41   308.30 79.15  AR-1221
  7
 36  40  96  98
 36  37  90  90
 39  46  90  90
 44  46  93  94
 45  46  95  97
 44  44  96  97
 43  43  97  97
  0
SURFACE SOIL CELLS WITH CAP
  6   6    0.0    0
  1  1.000E-41    1.0000E-41   308.30 79.15  AR-1221
  6
 39  39  91  92
 41  41  92  95
 42  42  92  92
 42  42  94  94
 45  45  91  92
 43  43  93  93
  0
```

```
CRARE 1&2 CADMIUM INPUT FILE BY S.C. CHEN ON 4/05/1994
1  1.00E+09  1000.0  10.0  0.00E-00
6 1 2 3 4 5 6
1
swtr.dat
1.80E-03
1


EAST VAULT FOR CRU-3: P:\ENGDATA\GEOT\KEEP\CR12NEW\CADMIUM\HELPAREA.DAT
   1   0.5118     .039   .02642     .340      .09     45.00      .39
CRU-3 : PLANT 2/3 AREA
   2   0.7500     .039   .02642     .340      .09     45.00      .39
CRU-3 : PLANT 9 AREA
   3   0.7500     .039   .02642     .340      .09     45.00      .39
CRU-3 : OTHER MAIN PLANT AREA
   4   7.5000     .039   .02642     .340      .09     45.00      .39
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
   5   7.5000    0.0390   0.0186    0.3400    0.0900   45.0000    0.3900
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
   6   0.9100    0.0390   0.0186    0.3400    0.0900   45.0000    0.3900


1
EAST VAULT FOR CRU-3 AND CRU-4 P:\ENGDATA\GEOT\KEEP\CR12NEW\CADMIUM
   1   1       0.  0
   1 8.895E+08 1.167E+02 3.18E+03 1.38E+02 CADMIUM
  26
  61  63  62  62
  60  63  63  63
  58  64  64  64
  57  64  65  65
  58  65  66  66
  59  65  67  67
  59  66  68  68
  60  67  69  69
  60  67  70  70
  61  68  71  71
  61  68  72  72
  62  69  73  73
  63  70  74  74
  63  70  75  75
  64  71  76  76
  64  71  77  77
  65  72  78  78
  65  72  79  79
  66  73  80  80
  67  74  81  81
  67  74  82  82
  67  74  83  83
  68  75  84  84
  68  75  85  85
  69  76  86  86
  70  71  87  87
   0
CRU-3 : PLANT 2/3 AREA
   2   2       0.0  0
   1 1.835E+08 7.800E-03  3.18E+03 1.38E+02 CADMIUM
   1
  47  50  76  79
   0
CRU-3 : PLANT 9 AREA
   3   3       0.0  0
   1 1.435E+08 1.220E-02  3.18E+03 1.38E+02 CADMIUM
   3
  58  60  74  75
  57  57  75  75
  58  58  76  76
   0
```

CRU-3 : OTHER MAIN PLANT BUILDINGS

```
 4   4      0.0  0
 1 4.176E+09 8.142E-03  3.18E+03 1.38E+02 CADMIUM
27
52  54  89  90
51  56  66  88
57  58  86  87
59  60  86  86
57  62  84  85
57  63  77  83
64  65  79  83
64  64  78  78
59  63  76  76
74  75  74  75
59  61  73  73
60  61  72  72
59  60  70  71
57  58  68  69
57  57  65  67
54  56  64  65
50  50  87  88
49  50  80  86
47  48  81  83
47  48  80  80
45  46  76  80
44  50  70  75
48  50  68  69
49  50  67  67
44  44  86  88
43  43  71  76
42  42  72  74
 0
```

SURFACE SOIL CELLS WITHOUT CAP

```
 5   5    0.0    0
 1  7.309E+08  1.1600E-02  2.618E+03 7.485E+01 CADMIUM
 7
36  40  96  98
36  37  90  90
39  46  90  90
44  46  93  94
45  46  95  97
44  44  96  97
43  43  97  97
 0
```

SURFACE SOIL CELLS WITH CAP

```
 6   6    0.0    0
 1  2.010E+08  1.1600E-02   2.618E+03 7.485E+01 CADMIUM
 6
39  39  91  92
41  41  92  95
42  42  92  92
42  42  94  94
45  45  91  92
43  43  93  93
 0
```

```
NP-237 4/05/94 CRARE:  P:\ENGDATA\GEOT\KEEP\CR12NEW\NP-237\SHEET.IN
1 1.0E+09   70.  10. 8.874e-10
4 1 2 3 4
1
swtr.dat
3.12E-08
1


 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
 1      7.5000    0.0390    0.0186    0.3400    0.0900   45.0000    0.3900
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
 2      0.9100    0.0390    0.0186    0.3400    0.0900   45.0000    0.3900
CRU-3 : PLANT 6 AREA
   3   0.7500     .039    .02642     .340      .09     45.00      .39
CRU-3 : PLANT 2/3 AREA
   4   0.7500     .039    .02642     .340      .09     45.00      .39


   1
SURFACE SOIL CELLS WITHOUT CAP : P:\ENGDATA\GEOT\KEEP\CR12NEW\NP237
   1   1    0.0    0
   1  8.937E+04     1.2895E-05   2.889E+02 31.77 Np-237
   7
  36  40  96  98
  36  37  90  90
  39  46  90  90
  44  46  93  94
  45  46  95  97
  44  44  96  97
  43  43  97  97
   0
SURFACE SOIL CELLS WITH CAP
   2   2    0.0    0
   1  2.458E+04     1.2895e-05   2.889E+02 31.77 Np-237
   6
  39  39  91  92
  41  41  92  95
  42  42  92  92
  42  42  94  94
  45  45  91  92
  43  43  93  93
   0
CRU-3 : PLANT 6 AREA
   3   3     0.0  0     1
   1 1.2414e+05 5.579e-04 2.889E+02 31.77 Np-237
   3
  57  58  70  72
  58  58  73  73
  59  59  72  72
   0
CRU-3 : PLANT 2/3 AREA
   4   4    0.0  0     1
   1 2.2476E+05 4.681E-04  2.889E+2 31.76 Np-237
   1
  47  50  76  79
   0
```

```
ANTIMONY   4/05/94 CRARE:  P:\ENGDATA\GEOT\KEEP\CR12NEW\ANTIMONY\SHEET.IN
1 1.0 1000.  10.  0.00e-00
6 1 2 3 4 5 6
1
SWTANT.new
1.50E-03
1


EAST VAULT FOR CRU-3: P:\ENGDATA\GEOT\KEEP\CR12NEW\ANTIMONY\HELPAREA.DAT
   1   0.5118     .039    .02642     .340      .09     45.00      .39
CRU-3 : PLANT 6 AREA
   2   0.7500     .039    .02642     .340      .09     45.00      .39
CRU-3 : PLANT 9 AREA
   3   0.7500     .039    .02642     .340      .09     45.00      .39
CRU-3 : OTHER MAIN PLANT AREA
   4   7.5000     .039    .02642     .340      .09     45.00      .39
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
   5     7.5000     0.0390    0.0186    0.3400    0.0900   45.0000    0.3900
 PO # 19, Scenario # 1, SURFACE SOIL CELLS LOADING TERMS
   6     0.9100     0.0390    0.0186    0.3400    0.0900   45.0000    0.3900


1
EAST VAULT - LOADED WITH OU4 & OU5 WASTES; OU3 DOES NOT CONTAIN ANTIMONY
   1   1       0.   0
   1 4.618E+09 1.451E-00 1590.0 515.0  Antimony
  26
  61   63   62   62
  60   63   63   63
  58   64   64   64
  57   64   65   65
  58   65   66   66
  59   65   67   67
  59   66   68   68
  60   67   69   69
  60   67   70   70
  61   68   71   71
  61   68   72   72
  62   69   73   73
  63   70   74   74
  63   70   75   75
  64   71   76   76
  64   71   77   77
  65   72   78   78
  65   72   79   79
  66   73   80   80
  67   74   81   81
  67   74   82   82
  67   74   83   83
  68   75   84   84
  68   75   85   85
  69   76   86   86
  70   71   87   87
   0
CRU-3 : PLANT 6 AREA
   2   2       0.0   0
   1 3.215E+08 4.085E-02  1.590E+03 515.0    Antimony
   3
  57   58   70   72
  58   58   73   73
  59   59   72   72
   0
CRU-3 : PLANT 9 AREA
   3   3       0.0   0
   1 7.985E+07 1.015E-02  1.590E+03 515.0    Antimony
   3
  58   60   74   75
  57   57   75   75
```

```
 58  58  76  76
  0
CRU-3 : OTHER MAIN PLANT BUILDINGS
  4   4     0.0  0
  1 8.539E+09 2.489E-02  1.590E+03 515.0      Antimony
 27
 52  54  89  90
 51  56  66  88
 57  58  86  87
 59  60  86  86
 57  62  84  85
 57  63  77  83
 64  65  79  83
 64  64  78  78
 59  63  76  76
 74  75  74  75
 59  61  73  73
 60  61  72  72
 59  60  70  71
 57  58  68  69
 57  57  65  67
 54  56  64  65
 50  50  87  88
 49  50  80  86
 47  48  81  83
 47  48  80  80
 45  46  76  80
 44  50  70  75
 48  50  68  69
 49  50  67  67
 44  44  86  88
 43  43  71  76
 42  42  72  74
  0
SURFACE SOIL CELLS WITHOUT CAP
  5   5    0.0    0
  1  3.428E+09     1.0880E-01   1.310E+03 278.   Antimony
  7
 36  40  96  98
 36  37  90  90
 39  46  90  90
 44  46  93  94
 45  46  95  97
 44  44  96  97
 43  43  97  97
  0
SURFACE SOIL CELLS WITH CAP
  6   6    0.0    0
  1  9.425E+08     1.0880e-01   1.310E+03 278.     Antimony
  6
 39  39  91  92
 41  41  92  95
 42  42  92  92
 42  42  94  94
 45  45  91  92
 43  43  93  93
  0
  1
```

ATTACHMENT I.II

U-238 MASS LOADINGS TO SWIFT III MODEL

EAST VAULT FOR CRU-3 - BLOCKS FROM UCRARE.WK3
P:\ENGDATA\GEOT\KEEP\CR12NEW\U-238

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.2635D+13	0.0000D+00	0.1186D+06
20.	0.2635D+13	0.0000D+00	0.2371D+06
30.	0.2635D+13	0.0000D+00	0.3557D+06
40.	0.2635D+13	0.0000D+00	0.4742D+06
50.	0.2635D+13	0.0000D+00	0.5928D+06
60.	0.2635D+13	0.0000D+00	0.7113D+06
70.	0.2635D+13	0.0000D+00	0.8299D+06
80.	0.2635D+13	0.0000D+00	0.9485D+06
90.	0.2635D+13	0.0000D+00	0.1067D+07
100.	0.2635D+13	0.0000D+00	0.1186D+07
110.	0.2635D+13	0.0000D+00	0.1304D+07
120.	0.2635D+13	0.0000D+00	0.1423D+07
130.	0.2635D+13	0.0000D+00	0.1541D+07
140.	0.2635D+13	0.0000D+00	0.1660D+07
150.	0.2635D+13	0.0000D+00	0.1778D+07
160.	0.2635D+13	0.0000D+00	0.1897D+07
170.	0.2635D+13	0.0000D+00	0.2015D+07
180.	0.2635D+13	0.0000D+00	0.2134D+07
190.	0.2635D+13	0.0000D+00	0.2253D+07
200.	0.2635D+13	0.0000D+00	0.2371D+07
210.	0.2635D+13	0.0000D+00	0.2490D+07
220.	0.2635D+13	0.0000D+00	0.2608D+07
230.	0.2635D+13	0.0000D+00	0.2727D+07
240.	0.2635D+13	0.0000D+00	0.2845D+07
250.	0.2635D+13	0.0000D+00	0.2964D+07
260.	0.2635D+13	0.0000D+00	0.3082D+07
270.	0.2635D+13	0.0000D+00	0.3201D+07
280.	0.2635D+13	0.0000D+00	0.3320D+07
290.	0.2635D+13	0.0000D+00	0.3438D+07
300.	0.2635D+13	0.0000D+00	0.3557D+07
310.	0.2635D+13	0.0000D+00	0.3675D+07
320.	0.2635D+13	0.0000D+00	0.3794D+07
330.	0.2635D+13	0.0000D+00	0.3912D+07
340.	0.2635D+13	0.0000D+00	0.4031D+07
350.	0.2635D+13	0.0000D+00	0.4150D+07
360.	0.2635D+13	0.0000D+00	0.4268D+07
370.	0.2635D+13	0.0000D+00	0.4387D+07
380.	0.2635D+13	0.0000D+00	0.4505D+07
390.	0.2635D+13	0.0000D+00	0.4624D+07
400.	0.2635D+13	0.0000D+00	0.4742D+07
410.	0.2635D+13	0.0000D+00	0.4861D+07
420.	0.2635D+13	0.0000D+00	0.4979D+07
430.	0.2635D+13	0.0000D+00	0.5098D+07
440.	0.2635D+13	0.0000D+00	0.5217D+07
450.	0.2635D+13	0.0000D+00	0.5335D+07
460.	0.2635D+13	0.0000D+00	0.5454D+07
470.	0.2635D+13	0.0000D+00	0.5572D+07
480.	0.2635D+13	0.0000D+00	0.5691D+07
490.	0.2635D+13	0.0000D+00	0.5809D+07
500.	0.2635D+13	0.0000D+00	0.5928D+07
510.	0.2635D+13	0.0000D+00	0.6046D+07
520.	0.2635D+13	0.0000D+00	0.6165D+07
530.	0.2635D+13	0.0000D+00	0.6284D+07
540.	0.2635D+13	0.0000D+00	0.6402D+07
550.	0.2635D+13	0.0000D+00	0.6521D+07
560.	0.2635D+13	0.0000D+00	0.6639D+07
570.	0.2635D+13	0.0000D+00	0.6758D+07
580.	0.2635D+13	0.0000D+00	0.6876D+07

590.	0.2635D+13	0.0000D+00	0.6995D+07
600.	0.2635D+13	0.0000D+00	0.7113D+07
610.	0.2635D+13	0.0000D+00	0.7232D+07
620.	0.2635D+13	0.0000D+00	0.7351D+07
630.	0.2635D+13	0.0000D+00	0.7469D+07
640.	0.2635D+13	0.0000D+00	0.7588D+07
650.	0.2635D+13	0.0000D+00	0.7706D+07
660.	0.2635D+13	0.0000D+00	0.7825D+07
670.	0.2635D+13	0.0000D+00	0.7943D+07
680.	0.2635D+13	0.0000D+00	0.8062D+07
690.	0.2635D+13	0.0000D+00	0.8180D+07
700.	0.2635D+13	0.0000D+00	0.8299D+07
710.	0.2635D+13	0.0000D+00	0.8418D+07
720.	0.2635D+13	0.0000D+00	0.8536D+07
730.	0.2635D+13	0.0000D+00	0.8655D+07
740.	0.2635D+13	0.0000D+00	0.8773D+07
750.	0.2635D+13	0.0000D+00	0.8892D+07
760.	0.2635D+13	0.0000D+00	0.9010D+07
770.	0.2635D+13	0.0000D+00	0.9129D+07
780.	0.2635D+13	0.0000D+00	0.9247D+07
790.	0.2635D+13	0.0000D+00	0.9366D+07
800.	0.2635D+13	0.0000D+00	0.9485D+07
810.	0.2635D+13	0.0000D+00	0.9603D+07
820.	0.2635D+13	0.0000D+00	0.9722D+07
830.	0.2635D+13	0.0000D+00	0.9840D+07
840.	0.2635D+13	0.0000D+00	0.9959D+07
850.	0.2635D+13	0.0000D+00	0.1008D+08
860.	0.2635D+13	0.0000D+00	0.1020D+08
870.	0.2635D+13	0.0000D+00	0.1031D+08
880.	0.2635D+13	0.0000D+00	0.1043D+08
890.	0.2635D+13	0.0000D+00	0.1055D+08
900.	0.2635D+13	0.0000D+00	0.1067D+08
910.	0.2635D+13	0.0000D+00	0.1079D+08
920.	0.2635D+13	0.0000D+00	0.1091D+08
930.	0.2635D+13	0.0000D+00	0.1103D+08
940.	0.2635D+13	0.0000D+00	0.1114D+08
950.	0.2635D+13	0.0000D+00	0.1126D+08
960.	0.2635D+13	0.0000D+00	0.1138D+08
970.	0.2635D+13	0.0000D+00	0.1150D+08
980.	0.2635D+13	0.0000D+00	0.1162D+08
990.	0.2635D+13	0.0000D+00	0.1174D+08
1000.	0.2635D+13	0.0000D+00	0.1186D+08

CRU-4 : SILOS 1 2 & 3 - CRU-4 RESIDUAL AREA

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.9283D+07	0.0000D+00	0.1547D+07
20.	0.7736D+07	0.0000D+00	0.3094D+07
30.	0.6189D+07	0.0000D+00	0.4641D+07
40.	0.4641D+07	0.0000D+00	0.6189D+07
50.	0.3094D+07	0.0000D+00	0.7736D+07
60.	0.1547D+07	0.4668D-81	0.9283D+07
70.	0.0000D+00	0.2325D-65	0.1083D+08
80.	0.0000D+00	0.5357D-53	0.1083D+08
90.	0.0000D+00	0.1639D-43	0.1083D+08
100.	0.0000D+00	0.4867D-36	0.1083D+08
110.	0.0000D+00	0.4922D-30	0.1083D+08
120.	0.0000D+00	0.3941D-25	0.1083D+08
130.	0.0000D+00	0.4498D-21	0.1083D+08
140.	0.0000D+00	0.1117D-17	0.1083D+08

150.	0.0000D+00	0.8237D-15	0.1083D+08
160.	0.0000D+00	0.2284D-12	0.1083D+08
170.	0.0000D+00	0.2850D-10	0.1083D+08
180.	0.0000D+00	0.1842D-08	0.1083D+08
190.	0.0000D+00	0.6888D-07	0.1083D+08
200.	0.0000D+00	0.1629D-05	0.1083D+08
210.	0.0000D+00	0.2619D-04	0.1083D+08
220.	0.0000D+00	0.3031D-03	0.1083D+08
230.	0.0000D+00	0.2652D-02	0.1083D+08
240.	0.0000D+00	0.1825D-01	0.1083D+08
250.	0.0000D+00	0.1020D+00	0.1083D+08
260.	0.0000D+00	0.4806D+00	0.1083D+08
270.	0.0000D+00	0.1923D+01	0.1083D+08
280.	0.0000D+00	0.6706D+01	0.1083D+08
290.	0.0000D+00	0.2073D+02	0.1083D+08
300.	0.0000D+00	0.5767D+02	0.1083D+08
310.	0.0000D+00	0.1462D+03	0.1083D+08
320.	0.0000D+00	0.3410D+03	0.1083D+08
330.	0.0000D+00	0.7394D+03	0.1083D+08
340.	0.0000D+00	0.1501D+04	0.1083D+08
350.	0.0000D+00	0.2874D+04	0.1083D+08
360.	0.0000D+00	0.5217D+04	0.1082D+08
370.	0.0000D+00	0.9027D+04	0.1082D+08
380.	0.0000D+00	0.1495D+05	0.1082D+08
390.	0.0000D+00	0.2381D+05	0.1081D+08
400.	0.0000D+00	0.3655D+05	0.1079D+08
410.	0.0000D+00	0.5427D+05	0.1078D+08
420.	0.0000D+00	0.7817D+05	0.1075D+08
430.	0.0000D+00	0.1095D+06	0.1072D+08
440.	0.0000D+00	0.1494D+06	0.1068D+08
450.	0.0000D+00	0.1990D+06	0.1063D+08
460.	0.0000D+00	0.2594D+06	0.1057D+08
470.	0.0000D+00	0.3312D+06	0.1050D+08
480.	0.0000D+00	0.4151D+06	0.1041D+08
490.	0.0000D+00	0.5114D+06	0.1032D+08
500.	0.0000D+00	0.6201D+06	0.1021D+08
510.	0.0000D+00	0.7410D+06	0.1009D+08
520.	0.0000D+00	0.8737D+06	0.9956D+07
530.	0.0000D+00	0.1018D+07	0.9812D+07
540.	0.0000D+00	0.1172D+07	0.9658D+07
550.	0.0000D+00	0.1337D+07	0.9493D+07
560.	0.0000D+00	0.1511D+07	0.9319D+07
570.	0.0000D+00	0.1693D+07	0.9137D+07
580.	0.0000D+00	0.1883D+07	0.8947D+07
590.	0.0000D+00	0.2081D+07	0.8749D+07
600.	0.0000D+00	0.2286D+07	0.8544D+07
610.	0.0000D+00	0.2497D+07	0.8333D+07
620.	0.0000D+00	0.2715D+07	0.8115D+07
630.	0.0000D+00	0.2939D+07	0.7891D+07
640.	0.0000D+00	0.3170D+07	0.7660D+07
650.	0.0000D+00	0.3406D+07	0.7424D+07
660.	0.0000D+00	0.3647D+07	0.7183D+07
670.	0.0000D+00	0.3895D+07	0.6935D+07
680.	0.0000D+00	0.4147D+07	0.6683D+07
690.	0.0000D+00	0.4403D+07	0.6427D+07
700.	0.0000D+00	0.4664D+07	0.6166D+07
710.	0.0000D+00	0.4928D+07	0.5902D+07
720.	0.0000D+00	0.5195D+07	0.5635D+07
730.	0.0000D+00	0.5463D+07	0.5367D+07
740.	0.0000D+00	0.5732D+07	0.5098D+07
750.	0.0000D+00	0.6001D+07	0.4829D+07
760.	0.0000D+00	0.6268D+07	0.4562D+07
770.	0.0000D+00	0.6533D+07	0.4297D+07
780.	0.0000D+00	0.6794D+07	0.4036D+07
790.	0.0000D+00	0.7051D+07	0.3779D+07

800.	0.0000D+00	0.7302D+07	0.3528D+07
810.	0.0000D+00	0.7546D+07	0.3284D+07
820.	0.0000D+00	0.7783D+07	0.3047D+07
830.	0.0000D+00	0.8011D+07	0.2819D+07
840.	0.0000D+00	0.8231D+07	0.2599D+07
850.	0.0000D+00	0.8440D+07	0.2390D+07
860.	0.0000D+00	0.8640D+07	0.2190D+07
870.	0.0000D+00	0.8829D+07	0.2001D+07
880.	0.0000D+00	0.9008D+07	0.1822D+07
890.	0.0000D+00	0.9176D+07	0.1654D+07
900.	0.0000D+00	0.9333D+07	0.1497D+07
910.	0.0000D+00	0.9479D+07	0.1351D+07
920.	0.0000D+00	0.9615D+07	0.1215D+07
930.	0.0000D+00	0.9740D+07	0.1090D+07
940.	0.0000D+00	0.9855D+07	0.9746D+06
950.	0.0000D+00	0.9961D+07	0.8689D+06
960.	0.0000D+00	0.1006D+08	0.7723D+06
970.	0.0000D+00	0.1015D+08	0.6846D+06
980.	0.0000D+00	0.1022D+08	0.6050D+06
990.	0.0000D+00	0.1030D+08	0.5332D+06
1000.	0.0000D+00	0.1036D+08	0.4686D+06

CRU-4 : SILOS 1 2 & 3 - CRU-4 PERCHED WATER

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.3051D+05	0.0000D+00	0.5084D+04
20.	0.2542D+05	0.0000D+00	0.1017D+05
30.	0.2034D+05	0.3071D-92	0.1525D+05
40.	0.1525D+05	0.1405D-63	0.2034D+05
50.	0.1017D+05	0.2108D-45	0.2542D+05
60.	0.5084D+04	0.1779D-33	0.3051D+05
70.	0.0000D+00	0.3653D-25	0.3559D+05
80.	0.0000D+00	0.3981D-19	0.3559D+05
90.	0.0000D+00	0.1310D-14	0.3559D+05
100.	0.0000D+00	0.3750D-11	0.3559D+05
110.	0.0000D+00	0.1848D-08	0.3559D+05
120.	0.0000D+00	0.2482D-06	0.3559D+05
130.	0.0000D+00	0.1253D-04	0.3559D+05
140.	0.0000D+00	0.2988D-03	0.3559D+05
150.	0.0000D+00	0.4077D-02	0.3559D+05
160.	0.0000D+00	0.3465D-01	0.3559D+05
170.	0.0000D+00	0.2049D+00	0.3559D+05
180.	0.0000D+00	0.9102D+00	0.3559D+05
190.	0.0000D+00	0.3214D+01	0.3559D+05
200.	0.0000D+00	0.9428D+01	0.3558D+05
210.	0.0000D+00	0.2378D+02	0.3557D+05
220.	0.0000D+00	0.5295D+02	0.3554D+05
230.	0.0000D+00	0.1063D+03	0.3548D+05
240.	0.0000D+00	0.1959D+03	0.3539D+05
250.	0.0000D+00	0.3354D+03	0.3525D+05
260.	0.0000D+00	0.5394D+03	0.3505D+05
270.	0.0000D+00	0.8220D+03	0.3477D+05
280.	0.0000D+00	0.1196D+04	0.3439D+05
290.	0.0000D+00	0.1670D+04	0.3392D+05
300.	0.0000D+00	0.2250D+04	0.3334D+05
310.	0.0000D+00	0.2941D+04	0.3265D+05
320.	0.0000D+00	0.3742D+04	0.3185D+05
330.	0.0000D+00	0.4650D+04	0.3094D+05
340.	0.0000D+00	0.5663D+04	0.2993D+05
350.	0.0000D+00	0.6774D+04	0.2882D+05

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360.	0.0000D+00	0.7978D+04	0.2761D+05
370.	0.0000D+00	0.9265D+04	0.2632D+05
380.	0.0000D+00	0.1063D+05	0.2496D+05
390.	0.0000D+00	0.1205D+05	0.2354D+05
400.	0.0000D+00	0.1352D+05	0.2207D+05
410.	0.0000D+00	0.1503D+05	0.2056D+05
420.	0.0000D+00	0.1655D+05	0.1904D+05
430.	0.0000D+00	0.1807D+05	0.1752D+05
440.	0.0000D+00	0.1957D+05	0.1602D+05
450.	0.0000D+00	0.2104D+05	0.1455D+05
460.	0.0000D+00	0.2245D+05	0.1314D+05
470.	0.0000D+00	0.2381D+05	0.1178D+05
480.	0.0000D+00	0.2509D+05	0.1050D+05
490.	0.0000D+00	0.2629D+05	0.9299D+04
500.	0.0000D+00	0.2740D+05	0.8187D+04
510.	0.0000D+00	0.2842D+05	0.7165D+04
520.	0.0000D+00	0.2935D+05	0.6235D+04
530.	0.0000D+00	0.3019D+05	0.5397D+04
540.	0.0000D+00	0.3094D+05	0.4646D+04
550.	0.0000D+00	0.3161D+05	0.3979D+04
560.	0.0000D+00	0.3220D+05	0.3391D+04
570.	0.0000D+00	0.3271D+05	0.2876D+04
580.	0.0000D+00	0.3316D+05	0.2428D+04
590.	0.0000D+00	0.3355D+05	0.2041D+04
600.	0.0000D+00	0.3388D+05	0.1708D+04
610.	0.0000D+00	0.3417D+05	0.1424D+04
620.	0.0000D+00	0.3441D+05	0.1183D+04
630.	0.0000D+00	0.3461D+05	0.9783D+03
640.	0.0000D+00	0.3478D+05	0.8065D+03
650.	0.0000D+00	0.3493D+05	0.6626D+03
660.	0.0000D+00	0.3505D+05	0.5426D+03
670.	0.0000D+00	0.3515D+05	0.4429D+03
680.	0.0000D+00	0.3523D+05	0.3605D+03
690.	0.0000D+00	0.3530D+05	0.2925D+03
700.	0.0000D+00	0.3535D+05	0.2367D+03
710.	0.0000D+00	0.3540D+05	0.1911D+03
720.	0.0000D+00	0.3544D+05	0.1538D+03
730.	0.0000D+00	0.3547D+05	0.1236D+03
740.	0.0000D+00	0.3549D+05	0.9900D+02
750.	0.0000D+00	0.3551D+05	0.7914D+02
760.	0.0000D+00	0.3553D+05	0.6313D+02
770.	0.0000D+00	0.3554D+05	0.5026D+02
780.	0.0000D+00	0.3555D+05	0.3993D+02
790.	0.0000D+00	0.3556D+05	0.3166D+02
800.	0.0000D+00	0.3556D+05	0.2506D+02
810.	0.0000D+00	0.3557D+05	0.1980D+02
820.	0.0000D+00	0.3557D+05	0.1562D+02
830.	0.0000D+00	0.3558D+05	0.1230D+02
840.	0.0000D+00	0.3558D+05	0.9672D+01
850.	0.0000D+00	0.3558D+05	0.7594D+01
860.	0.0000D+00	0.3558D+05	0.5953D+01
870.	0.0000D+00	0.3559D+05	0.4661D+01
880.	0.0000D+00	0.3559D+05	0.3644D+01
890.	0.0000D+00	0.3559D+05	0.2845D+01
900.	0.0000D+00	0.3559D+05	0.2219D+01
910.	0.0000D+00	0.3559D+05	0.1728D+01
920.	0.0000D+00	0.3559D+05	0.1345D+01
930.	0.0000D+00	0.3559D+05	0.1045D+01
940.	0.0000D+00	0.3559D+05	0.8119D+00
950.	0.0000D+00	0.3559D+05	0.6299D+00
960.	0.0000D+00	0.3559D+05	0.4883D+00
970.	0.0000D+00	0.3559D+05	0.3783D+00
980.	0.0000D+00	0.3559D+05	0.2929D+00
990.	0.0000D+00	0.3559D+05	0.2267D+00
1000.	0.0000D+00	0.3559D+05	0.1752D+00

CRU-3 : WEST OF PLANT AREA

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.8511D+09	0.0000D+00	0.2308D+08
20.	0.8280D+09	0.0000D+00	0.4616D+08
30.	0.8050D+09	0.0000D+00	0.6923D+08
40.	0.7819D+09	0.0000D+00	0.9231D+08
50.	0.7588D+09	0.0000D+00	0.1154D+09
60.	0.7357D+09	0.0000D+00	0.1385D+09
70.	0.7127D+09	0.0000D+00	0.1615D+09
80.	0.6896D+09	0.0000D+00	0.1846D+09
90.	0.6665D+09	0.0000D+00	0.2077D+09
100.	0.6434D+09	0.0000D+00	0.2308D+09
110.	0.6203D+09	0.0000D+00	0.2539D+09
120.	0.5973D+09	0.0000D+00	0.2769D+09
130.	0.5742D+09	0.0000D+00	0.3000D+09
140.	0.5511D+09	0.0000D+00	0.3231D+09
150.	0.5280D+09	0.0000D+00	0.3462D+09
160.	0.5050D+09	0.0000D+00	0.3692D+09
170.	0.4819D+09	0.0000D+00	0.3923D+09
180.	0.4588D+09	0.0000D+00	0.4154D+09
190.	0.4357D+09	0.0000D+00	0.4385D+09
200.	0.4126D+09	0.0000D+00	0.4616D+09
210.	0.3896D+09	0.0000D+00	0.4846D+09
220.	0.3665D+09	0.0000D+00	0.5077D+09
230.	0.3434D+09	0.0000D+00	0.5308D+09
240.	0.3203D+09	0.0000D+00	0.5539D+09
250.	0.2973D+09	0.0000D+00	0.5769D+09
260.	0.2742D+09	0.0000D+00	0.6000D+09
270.	0.2511D+09	0.0000D+00	0.6231D+09
280.	0.2280D+09	0.0000D+00	0.6462D+09
290.	0.2049D+09	0.0000D+00	0.6693D+09
300.	0.1819D+09	0.0000D+00	0.6923D+09
310.	0.1588D+09	0.0000D+00	0.7154D+09
320.	0.1357D+09	0.0000D+00	0.7385D+09
330.	0.1126D+09	0.0000D+00	0.7616D+09
340.	0.8956D+08	0.0000D+00	0.7846D+09
350.	0.6648D+08	0.0000D+00	0.8077D+09
360.	0.4340D+08	0.0000D+00	0.8308D+09
370.	0.2032D+08	0.0000D+00	0.8539D+09
380.	0.0000D+00	0.0000D+00	0.8742D+09
390.	0.0000D+00	0.0000D+00	0.8742D+09
400.	0.0000D+00	0.0000D+00	0.8742D+09
410.	0.0000D+00	0.0000D+00	0.8742D+09
420.	0.0000D+00	0.0000D+00	0.8742D+09
430.	0.0000D+00	0.0000D+00	0.8742D+09
440.	0.0000D+00	0.0000D+00	0.8742D+09
450.	0.0000D+00	0.0000D+00	0.8742D+09
460.	0.0000D+00	0.0000D+00	0.8742D+09
470.	0.0000D+00	0.0000D+00	0.8742D+09
480.	0.0000D+00	0.0000D+00	0.8742D+09
490.	0.0000D+00	0.0000D+00	0.8742D+09
500.	0.0000D+00	0.0000D+00	0.8742D+09
510.	0.0000D+00	0.0000D+00	0.8742D+09
520.	0.0000D+00	0.0000D+00	0.8742D+09
530.	0.0000D+00	0.0000D+00	0.8742D+09
540.	0.0000D+00	0.0000D+00	0.8742D+09
550.	0.0000D+00	0.0000D+00	0.8742D+09
560.	0.0000D+00	0.0000D+00	0.8742D+09
570.	0.0000D+00	0.0000D+00	0.8742D+09

580.	0.0000D+00	0.0000D+00	0.8742D+09
590.	0.0000D+00	0.0000D+00	0.8742D+09
600.	0.0000D+00	0.0000D+00	0.8742D+09
610.	0.0000D+00	0.0000D+00	0.8742D+09
620.	0.0000D+00	0.0000D+00	0.8742D+09
630.	0.0000D+00	0.0000D+00	0.8742D+09
640.	0.0000D+00	0.0000D+00	0.8742D+09
650.	0.0000D+00	0.0000D+00	0.8742D+09
660.	0.0000D+00	0.0000D+00	0.8742D+09
670.	0.0000D+00	0.0000D+00	0.8742D+09
680.	0.0000D+00	0.0000D+00	0.8742D+09
690.	0.0000D+00	0.0000D+00	0.8742D+09
700.	0.0000D+00	0.0000D+00	0.8742D+09
710.	0.0000D+00	0.0000D+00	0.8742D+09
720.	0.0000D+00	0.0000D+00	0.8742D+09
730.	0.0000D+00	0.0000D+00	0.8742D+09
740.	0.0000D+00	0.0000D+00	0.8742D+09
750.	0.0000D+00	0.0000D+00	0.8742D+09
760.	0.0000D+00	0.0000D+00	0.8742D+09
770.	0.0000D+00	0.0000D+00	0.8742D+09
780.	0.0000D+00	0.0000D+00	0.8742D+09
790.	0.0000D+00	0.0000D+00	0.8742D+09
800.	0.0000D+00	0.0000D+00	0.8742D+09
810.	0.0000D+00	0.0000D+00	0.8742D+09
820.	0.0000D+00	0.0000D+00	0.8742D+09
830.	0.0000D+00	0.0000D+00	0.8742D+09
840.	0.0000D+00	0.0000D+00	0.8742D+09
850.	0.0000D+00	0.0000D+00	0.8742D+09
860.	0.0000D+00	0.0000D+00	0.8742D+09
870.	0.0000D+00	0.0000D+00	0.8742D+09
880.	0.0000D+00	0.0000D+00	0.8742D+09
890.	0.0000D+00	0.0000D+00	0.8742D+09
900.	0.0000D+00	0.0000D+00	0.8742D+09
910.	0.0000D+00	0.0000D+00	0.8742D+09
920.	0.0000D+00	0.0000D+00	0.8742D+09
930.	0.0000D+00	0.0000D+00	0.8742D+09
940.	0.0000D+00	0.0000D+00	0.8742D+09
950.	0.0000D+00	0.0000D+00	0.8742D+09
960.	0.0000D+00	0.0000D+00	0.8742D+09
970.	0.0000D+00	0.0000D+00	0.8742D+09
980.	0.0000D+00	0.0000D+00	0.8742D+09
990.	0.0000D+00	0.0000D+00	0.8742D+09
1000.	0.0000D+00	0.0000D+00	0.8742D+09

CRU-3 : WEST OF PLANT AREA PERCHED WATER

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.4576D+05	0.0000D+00	0.7627D+04
20.	0.3814D+05	0.0000D+00	0.1525D+05
30.	0.3051D+05	0.0000D+00	0.2288D+05
40.	0.2288D+05	0.0000D+00	0.3051D+05
50.	0.1525D+05	0.0000D+00	0.3814D+05
60.	0.7627D+04	0.0000D+00	0.4576D+05
70.	0.0000D+00	0.0000D+00	0.5339D+05
80.	0.0000D+00	0.0000D+00	0.5339D+05
90.	0.0000D+00	0.0000D+00	0.5339D+05
100.	0.0000D+00	0.0000D+00	0.5339D+05
110.	0.0000D+00	0.0000D+00	0.5339D+05
120.	0.0000D+00	0.0000D+00	0.5339D+05
130.	0.0000D+00	0.0000D+00	0.5339D+05

140.	0.0000D+00	0.0000D+00	0.5339D+05
150.	0.0000D+00	0.0000D+00	0.5339D+05
160.	0.0000D+00	0.0000D+00	0.5339D+05
170.	0.0000D+00	0.0000D+00	0.5339D+05
180.	0.0000D+00	0.0000D+00	0.5339D+05
190.	0.0000D+00	0.0000D+00	0.5339D+05
200.	0.0000D+00	0.0000D+00	0.5339D+05
210.	0.0000D+00	0.0000D+00	0.5339D+05
220.	0.0000D+00	0.0000D+00	0.5339D+05
230.	0.0000D+00	0.0000D+00	0.5339D+05
240.	0.0000D+00	0.0000D+00	0.5339D+05
250.	0.0000D+00	0.0000D+00	0.5339D+05
260.	0.0000D+00	0.0000D+00	0.5339D+05
270.	0.0000D+00	0.0000D+00	0.5339D+05
280.	0.0000D+00	0.0000D+00	0.5339D+05
290.	0.0000D+00	0.0000D+00	0.5339D+05
300.	0.0000D+00	0.0000D+00	0.5339D+05
310.	0.0000D+00	0.0000D+00	0.5339D+05
320.	0.0000D+00	0.0000D+00	0.5339D+05
330.	0.0000D+00	0.0000D+00	0.5339D+05
340.	0.0000D+00	0.0000D+00	0.5339D+05
350.	0.0000D+00	0.0000D+00	0.5339D+05
360.	0.0000D+00	0.0000D+00	0.5339D+05
370.	0.0000D+00	0.0000D+00	0.5339D+05
380.	0.0000D+00	0.0000D+00	0.5339D+05
390.	0.0000D+00	0.0000D+00	0.5339D+05
400.	0.0000D+00	0.0000D+00	0.5339D+05
410.	0.0000D+00	0.0000D+00	0.5339D+05
420.	0.0000D+00	0.0000D+00	0.5339D+05
430.	0.0000D+00	0.0000D+00	0.5339D+05
440.	0.0000D+00	0.0000D+00	0.5339D+05
450.	0.0000D+00	0.0000D+00	0.5339D+05
460.	0.0000D+00	0.0000D+00	0.5339D+05
470.	0.0000D+00	0.0000D+00	0.5339D+05
480.	0.0000D+00	0.0000D+00	0.5339D+05
490.	0.0000D+00	0.0000D+00	0.5339D+05
500.	0.0000D+00	0.0000D+00	0.5339D+05
510.	0.0000D+00	0.0000D+00	0.5339D+05
520.	0.0000D+00	0.0000D+00	0.5339D+05
530.	0.0000D+00	0.0000D+00	0.5339D+05
540.	0.0000D+00	0.0000D+00	0.5339D+05
550.	0.0000D+00	0.0000D+00	0.5339D+05
560.	0.0000D+00	0.0000D+00	0.5339D+05
570.	0.0000D+00	0.0000D+00	0.5339D+05
580.	0.0000D+00	0.0000D+00	0.5339D+05
590.	0.0000D+00	0.0000D+00	0.5339D+05
600.	0.0000D+00	0.0000D+00	0.5339D+05
610.	0.0000D+00	0.0000D+00	0.5339D+05
620.	0.0000D+00	0.0000D+00	0.5339D+05
630.	0.0000D+00	0.0000D+00	0.5339D+05
640.	0.0000D+00	0.0000D+00	0.5339D+05
650.	0.0000D+00	0.1349D-80	0.5339D+05
660.	0.0000D+00	0.1188D-61	0.5339D+05
670.	0.0000D+00	0.1990D-55	0.5339D+05
680.	0.0000D+00	0.2223D-53	0.5339D+05
690.	0.0000D+00	0.7657D-52	0.5339D+05
700.	0.0000D+00	0.9460D-51	0.5339D+05
710.	0.0000D+00	0.8881D-50	0.5339D+05
720.	0.0000D+00	0.7604D-49	0.5339D+05
730.	0.0000D+00	0.6098D-48	0.5339D+05
740.	0.0000D+00	0.4608D-47	0.5339D+05
750.	0.0000D+00	0.3291D-46	0.5339D+05
760.	0.0000D+00	0.2228D-45	0.5339D+05
770.	0.0000D+00	0.1431D-44	0.5339D+05
780.	0.0000D+00	0.8751D-44	0.5339D+05

790.	0.0000D+00	0.5101D-43	0.5339D+05
800.	0.0000D+00	0.2839D-42	0.5339D+05
810.	0.0000D+00	0.1512D-41	0.5339D+05
820.	0.0000D+00	0.7719D-41	0.5339D+05
830.	0.0000D+00	0.3782D-40	0.5339D+05
840.	0.0000D+00	0.1781D-39	0.5339D+05
850.	0.0000D+00	0.8076D-39	0.5339D+05
860.	0.0000D+00	0.3530D-38	0.5339D+05
870.	0.0000D+00	0.1489D-37	0.5339D+05
880.	0.0000D+00	0.6072D-37	0.5339D+05
890.	0.0000D+00	0.2396D-36	0.5339D+05
900.	0.0000D+00	0.9157D-36	0.5339D+05
910.	0.0000D+00	0.3354D-35	0.5339D+05
920.	0.0000D+00	0.1233D-34	0.5339D+05
930.	0.0000D+00	0.4226D-34	0.5339D+05
940.	0.0000D+00	0.1469D-33	0.5339D+05
950.	0.0000D+00	0.4746D-33	0.5339D+05
960.	0.0000D+00	0.1574D-32	0.5339D+05
970.	0.0000D+00	0.4792D-32	0.5339D+05
980.	0.0000D+00	0.1530D-31	0.5339D+05
990.	0.0000D+00	0.4368D-31	0.5339D+05
1000.	0.0000D+00	0.1360D-30	0.5339D+05

CRU-3 : EAST OF PLANT AREA

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.3972D+09	0.0000D+00	0.1077D+08
20.	0.3865D+09	0.0000D+00	0.2154D+08
30.	0.3757D+09	0.0000D+00	0.3231D+08
40.	0.3649D+09	0.0000D+00	0.4308D+08
50.	0.3542D+09	0.0000D+00	0.5385D+08
60.	0.3434D+09	0.0000D+00	0.6462D+08
70.	0.3326D+09	0.0000D+00	0.7539D+08
80.	0.3218D+09	0.0000D+00	0.8616D+08
90.	0.3111D+09	0.0000D+00	0.9693D+08
100.	0.3003D+09	0.0000D+00	0.1077D+09
110.	0.2895D+09	0.0000D+00	0.1185D+09
120.	0.2788D+09	0.0000D+00	0.1292D+09
130.	0.2680D+09	0.0000D+00	0.1400D+09
140.	0.2572D+09	0.0000D+00	0.1508D+09
150.	0.2465D+09	0.0000D+00	0.1615D+09
160.	0.2357D+09	0.0000D+00	0.1723D+09
170.	0.2249D+09	0.0000D+00	0.1831D+09
180.	0.2141D+09	0.0000D+00	0.1939D+09
190.	0.2034D+09	0.0000D+00	0.2046D+09
200.	0.1926D+09	0.0000D+00	0.2154D+09
210.	0.1818D+09	0.0000D+00	0.2262D+09
220.	0.1711D+09	0.0000D+00	0.2369D+09
230.	0.1603D+09	0.0000D+00	0.2477D+09
240.	0.1495D+09	0.0000D+00	0.2585D+09
250.	0.1388D+09	0.0000D+00	0.2692D+09
260.	0.1280D+09	0.0000D+00	0.2800D+09
270.	0.1172D+09	0.0000D+00	0.2908D+09
280.	0.1065D+09	0.0000D+00	0.3015D+09
290.	0.9568D+08	0.0000D+00	0.3123D+09
300.	0.8491D+08	0.0000D+00	0.3231D+09
310.	0.7414D+08	0.0000D+00	0.3339D+09
320.	0.6337D+08	0.0000D+00	0.3446D+09
330.	0.5260D+08	0.0000D+00	0.3554D+09
340.	0.4183D+08	0.0000D+00	0.3662D+09

350.	0.3106D+08	0.0000D+00	0.3769D+09
360.	0.2029D+08	0.0000D+00	0.3877D+09
370.	0.9524D+07	0.0000D+00	0.3985D+09
380.	0.0000D+00	0.0000D+00	0.4080D+09
390.	0.0000D+00	0.0000D+00	0.4080D+09
400.	0.0000D+00	0.0000D+00	0.4080D+09
410.	0.0000D+00	0.0000D+00	0.4080D+09
420.	0.0000D+00	0.0000D+00	0.4080D+09
430.	0.0000D+00	0.0000D+00	0.4080D+09
440.	0.0000D+00	0.0000D+00	0.4080D+09
450.	0.0000D+00	0.0000D+00	0.4080D+09
460.	0.0000D+00	0.0000D+00	0.4080D+09
470.	0.0000D+00	0.0000D+00	0.4080D+09
480.	0.0000D+00	0.0000D+00	0.4080D+09
490.	0.0000D+00	0.0000D+00	0.4080D+09
500.	0.0000D+00	0.0000D+00	0.4080D+09
510.	0.0000D+00	0.0000D+00	0.4080D+09
520.	0.0000D+00	0.0000D+00	0.4080D+09
530.	0.0000D+00	0.0000D+00	0.4080D+09
540.	0.0000D+00	0.0000D+00	0.4080D+09
550.	0.0000D+00	0.0000D+00	0.4080D+09
560.	0.0000D+00	0.0000D+00	0.4080D+09
570.	0.0000D+00	0.0000D+00	0.4080D+09
580.	0.0000D+00	0.0000D+00	0.4080D+09
590.	0.0000D+00	0.0000D+00	0.4080D+09
600.	0.0000D+00	0.0000D+00	0.4080D+09
610.	0.0000D+00	0.0000D+00	0.4080D+09
620.	0.0000D+00	0.0000D+00	0.4080D+09
630.	0.0000D+00	0.0000D+00	0.4080D+09
640.	0.0000D+00	0.0000D+00	0.4080D+09
650.	0.0000D+00	0.0000D+00	0.4080D+09
660.	0.0000D+00	0.0000D+00	0.4080D+09
670.	0.0000D+00	0.0000D+00	0.4080D+09
680.	0.0000D+00	0.0000D+00	0.4080D+09
690.	0.0000D+00	0.0000D+00	0.4080D+09
700.	0.0000D+00	0.0000D+00	0.4080D+09
710.	0.0000D+00	0.0000D+00	0.4080D+09
720.	0.0000D+00	0.0000D+00	0.4080D+09
730.	0.0000D+00	0.0000D+00	0.4080D+09
740.	0.0000D+00	0.0000D+00	0.4080D+09
750.	0.0000D+00	0.0000D+00	0.4080D+09
760.	0.0000D+00	0.0000D+00	0.4080D+09
770.	0.0000D+00	0.0000D+00	0.4080D+09
780.	0.0000D+00	0.0000D+00	0.4080D+09
790.	0.0000D+00	0.0000D+00	0.4080D+09
800.	0.0000D+00	0.0000D+00	0.4080D+09
810.	0.0000D+00	0.0000D+00	0.4080D+09
820.	0.0000D+00	0.0000D+00	0.4080D+09
830.	0.0000D+00	0.0000D+00	0.4080D+09
840.	0.0000D+00	0.0000D+00	0.4080D+09
850.	0.0000D+00	0.0000D+00	0.4080D+09
860.	0.0000D+00	0.0000D+00	0.4080D+09
870.	0.0000D+00	0.0000D+00	0.4080D+09
880.	0.0000D+00	0.0000D+00	0.4080D+09
890.	0.0000D+00	0.0000D+00	0.4080D+09
900.	0.0000D+00	0.0000D+00	0.4080D+09
910.	0.0000D+00	0.0000D+00	0.4080D+09
920.	0.0000D+00	0.0000D+00	0.4080D+09
930.	0.0000D+00	0.0000D+00	0.4080D+09
940.	0.0000D+00	0.0000D+00	0.4080D+09
950.	0.0000D+00	0.0000D+00	0.4080D+09
960.	0.0000D+00	0.0000D+00	0.4080D+09
970.	0.0000D+00	0.0000D+00	0.4080D+09
980.	0.0000D+00	0.0000D+00	0.4080D+09
990.	0.0000D+00	0.0000D+00	0.4080D+09

1000.	0.0000D+00	0.0000D+00	0.4080D+09

CRU-3 : EAST OF PLANT AREA PERCHED WATER

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.2136D+05	0.0000D+00	0.3560D+04
20.	0.1780D+05	0.0000D+00	0.7120D+04
30.	0.1424D+05	0.0000D+00	0.1068D+05
40.	0.1068D+05	0.0000D+00	0.1424D+05
50.	0.7120D+04	0.0000D+00	0.1780D+05
60.	0.3560D+04	0.0000D+00	0.2136D+05
70.	0.0000D+00	0.0000D+00	0.2492D+05
80.	0.0000D+00	0.0000D+00	0.2492D+05
90.	0.0000D+00	0.0000D+00	0.2492D+05
100.	0.0000D+00	0.0000D+00	0.2492D+05
110.	0.0000D+00	0.0000D+00	0.2492D+05
120.	0.0000D+00	0.0000D+00	0.2492D+05
130.	0.0000D+00	0.0000D+00	0.2492D+05
140.	0.0000D+00	0.0000D+00	0.2492D+05
150.	0.0000D+00	0.0000D+00	0.2492D+05
160.	0.0000D+00	0.0000D+00	0.2492D+05
170.	0.0000D+00	0.0000D+00	0.2492D+05
180.	0.0000D+00	0.0000D+00	0.2492D+05
190.	0.0000D+00	0.0000D+00	0.2492D+05
200.	0.0000D+00	0.0000D+00	0.2492D+05
210.	0.0000D+00	0.0000D+00	0.2492D+05
220.	0.0000D+00	0.0000D+00	0.2492D+05
230.	0.0000D+00	0.0000D+00	0.2492D+05
240.	0.0000D+00	0.0000D+00	0.2492D+05
250.	0.0000D+00	0.0000D+00	0.2492D+05
260.	0.0000D+00	0.0000D+00	0.2492D+05
270.	0.0000D+00	0.0000D+00	0.2492D+05
280.	0.0000D+00	0.0000D+00	0.2492D+05
290.	0.0000D+00	0.0000D+00	0.2492D+05
300.	0.0000D+00	0.0000D+00	0.2492D+05
310.	0.0000D+00	0.0000D+00	0.2492D+05
320.	0.0000D+00	0.0000D+00	0.2492D+05
330.	0.0000D+00	0.0000D+00	0.2492D+05
340.	0.0000D+00	0.0000D+00	0.2492D+05
350.	0.0000D+00	0.0000D+00	0.2492D+05
360.	0.0000D+00	0.0000D+00	0.2492D+05
370.	0.0000D+00	0.0000D+00	0.2492D+05
380.	0.0000D+00	0.0000D+00	0.2492D+05
390.	0.0000D+00	0.0000D+00	0.2492D+05
400.	0.0000D+00	0.0000D+00	0.2492D+05
410.	0.0000D+00	0.0000D+00	0.2492D+05
420.	0.0000D+00	0.0000D+00	0.2492D+05
430.	0.0000D+00	0.0000D+00	0.2492D+05
440.	0.0000D+00	0.0000D+00	0.2492D+05
450.	0.0000D+00	0.0000D+00	0.2492D+05
460.	0.0000D+00	0.0000D+00	0.2492D+05
470.	0.0000D+00	0.0000D+00	0.2492D+05
480.	0.0000D+00	0.0000D+00	0.2492D+05
490.	0.0000D+00	0.0000D+00	0.2492D+05
500.	0.0000D+00	0.4041-100	0.2492D+05
510.	0.0000D+00	0.1379D-81	0.2492D+05
520.	0.0000D+00	0.1646D-70	0.2492D+05
530.	0.0000D+00	0.1748D-63	0.2492D+05
540.	0.0000D+00	0.1290D-59	0.2492D+05
550.	0.0000D+00	0.2154D-56	0.2492D+05

560.	0.0000D+00	0.3697D-54	0.2492D+05
570.	0.0000D+00	0.1674D-52	0.2492D+05
580.	0.0000D+00	0.3969D-51	0.2492D+05
590.	0.0000D+00	0.7206D-50	0.2492D+05
600.	0.0000D+00	0.1145D-48	0.2492D+05
610.	0.0000D+00	0.1640D-47	0.2492D+05
620.	0.0000D+00	0.2134D-46	0.2492D+05
630.	0.0000D+00	0.2535D-45	0.2492D+05
640.	0.0000D+00	0.2762D-44	0.2492D+05
650.	0.0000D+00	0.2772D-43	0.2492D+05
660.	0.0000D+00	0.2573D-42	0.2492D+05
670.	0.0000D+00	0.2217D-41	0.2492D+05
680.	0.0000D+00	0.1780D-40	0.2492D+05
690.	0.0000D+00	0.1336D-39	0.2492D+05
700.	0.0000D+00	0.9400D-39	0.2492D+05
710.	0.0000D+00	0.6221D-38	0.2492D+05
720.	0.0000D+00	0.3882D-37	0.2492D+05
730.	0.0000D+00	0.2291D-36	0.2492D+05
740.	0.0000D+00	0.1281D-35	0.2492D+05
750.	0.0000D+00	0.6809D-35	0.2492D+05
760.	0.0000D+00	0.3445D-34	0.2492D+05
770.	0.0000D+00	0.1663D-33	0.2492D+05
780.	0.0000D+00	0.7673D-33	0.2492D+05
790.	0.0000D+00	0.3391D-32	0.2492D+05
800.	0.0000D+00	0.1438D-31	0.2492D+05
810.	0.0000D+00	0.5860D-31	0.2492D+05
820.	0.0000D+00	0.2298D-30	0.2492D+05
830.	0.0000D+00	0.8691D-30	0.2492D+05
840.	0.0000D+00	0.3172D-29	0.2492D+05
850.	0.0000D+00	0.1119D-28	0.2492D+05
860.	0.0000D+00	0.3823D-28	0.2492D+05
870.	0.0000D+00	0.1265D-27	0.2492D+05
880.	0.0000D+00	0.4063D-27	0.2492D+05
890.	0.0000D+00	0.1267D-26	0.2492D+05
900.	0.0000D+00	0.3848D-26	0.2492D+05
910.	0.0000D+00	0.1134D-25	0.2492D+05
920.	0.0000D+00	0.3268D-25	0.2492D+05
930.	0.0000D+00	0.9139D-25	0.2492D+05
940.	0.0000D+00	0.2509D-24	0.2492D+05
950.	0.0000D+00	0.6676D-24	0.2492D+05
960.	0.0000D+00	0.1755D-23	0.2492D+05
970.	0.0000D+00	0.4445D-23	0.2492D+05
980.	0.0000D+00	0.1128D-22	0.2492D+05
990.	0.0000D+00	0.2707D-22	0.2492D+05
1000.	0.0000D+00	0.6717D-22	0.2492D+05

CRU-3 : PLANT 2/3 AREA

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.9300D+09	0.0000D+00	0.2458D+07
20.	0.9276D+09	0.0000D+00	0.4910D+07
30.	0.9251D+09	0.0000D+00	0.7356D+07
40.	0.9227D+09	0.0000D+00	0.9795D+07
50.	0.9203D+09	0.0000D+00	0.1223D+08
60.	0.9178D+09	0.0000D+00	0.1465D+08
70.	0.9154D+09	0.0000D+00	0.1707D+08
80.	0.9130D+09	0.0000D+00	0.1949D+08
90.	0.9106D+09	0.0000D+00	0.2189D+08
100.	0.9082D+09	0.0000D+00	0.2429D+08
110.	0.9058D+09	0.0000D+00	0.2669D+08

120.	0.9034D+09	0.0000D+00	0.2908D+08
130.	0.9010D+09	0.0000D+00	0.3146D+08
140.	0.8987D+09	0.0000D+00	0.3383D+08
150.	0.8963D+09	0.0000D+00	0.3620D+08
160.	0.8939D+09	0.0000D+00	0.3857D+08
170.	0.8916D+09	0.7955-105	0.4092D+08
180.	0.8892D+09	0.1244D-94	0.4327D+08
190.	0.8869D+09	0.1501D-86	0.4562D+08
200.	0.8845D+09	0.1882D-80	0.4796D+08
210.	0.8822D+09	0.1476D-75	0.5029D+08
220.	0.8799D+09	0.2215D-71	0.5261D+08
230.	0.8776D+09	0.1192D-67	0.5493D+08
240.	0.8753D+09	0.3032D-64	0.5725D+08
250.	0.8729D+09	0.4110D-61	0.5955D+08
260.	0.8706D+09	0.3204D-58	0.6186D+08
270.	0.8683D+09	0.1527D-55	0.6415D+08
280.	0.8661D+09	0.4690D-53	0.6644D+08
290.	0.8638D+09	0.9711D-51	0.6872D+08
300.	0.8615D+09	0.1409D-48	0.7100D+08
310.	0.8592D+09	0.1484D-46	0.7327D+08
320.	0.8570D+09	0.1167D-44	0.7554D+08
330.	0.8547D+09	0.7049D-43	0.7780D+08
340.	0.8525D+09	0.3342D-41	0.8005D+08
350.	0.8502D+09	0.1270D-39	0.8230D+08
360.	0.8480D+09	0.3941D-38	0.8454D+08
370.	0.8457D+09	0.1015D-36	0.8677D+08
380.	0.8435D+09	0.2201D-35	0.8900D+08
390.	0.8413D+09	0.4074D-34	0.9123D+08
400.	0.8391D+09	0.6509D-33	0.9344D+08
410.	0.8368D+09	0.9077D-32	0.9566D+08
420.	0.8346D+09	0.1115D-30	0.9786D+08
430.	0.8324D+09	0.1218D-29	0.1001D+09
440.	0.8302D+09	0.1192D-28	0.1023D+09
450.	0.8281D+09	0.1053D-27	0.1044D+09
460.	0.8259D+09	0.8455D-27	0.1066D+09
470.	0.8237D+09	0.6204D-26	0.1088D+09
480.	0.8215D+09	0.4185D-25	0.1110D+09
490.	0.8194D+09	0.2609D-24	0.1131D+09
500.	0.8172D+09	0.1510D-23	0.1153D+09
510.	0.8150D+09	0.8147D-23	0.1175D+09
520.	0.8129D+09	0.4116D-22	0.1196D+09
530.	0.8107D+09	0.1954D-21	0.1218D+09
540.	0.8086D+09	0.8745D-21	0.1239D+09
550.	0.8065D+09	0.3702D-20	0.1260D+09
560.	0.8044D+09	0.1487D-19	0.1281D+09
570.	0.8022D+09	0.5684D-19	0.1303D+09
580.	0.8001D+09	0.2072D-18	0.1324D+09
590.	0.7980D+09	0.7221D-18	0.1345D+09
600.	0.7959D+09	0.2412D-17	0.1366D+09
610.	0.7938D+09	0.7734D-17	0.1387D+09
620.	0.7917D+09	0.2386D-16	0.1408D+09
630.	0.7896D+09	0.7098D-16	0.1429D+09
640.	0.7875D+09	0.2038D-15	0.1450D+09
650.	0.7855D+09	0.5661D-15	0.1470D+09
660.	0.7834D+09	0.1523D-14	0.1491D+09
670.	0.7813D+09	0.3974D-14	0.1512D+09
680.	0.7793D+09	0.1007D-13	0.1532D+09
690.	0.7772D+09	0.2482D-13	0.1553D+09
700.	0.7752D+09	0.5958D-13	0.1573D+09
710.	0.7731D+09	0.1394D-12	0.1594D+09
720.	0.7711D+09	0.3182D-12	0.1614D+09
730.	0.7691D+09	0.7095D-12	0.1634D+09
740.	0.7670D+09	0.1547D-11	0.1655D+09
750.	0.7650D+09	0.3300D-11	0.1675D+09
760.	0.7630D+09	0.6897D-11	0.1695D+09

770.	0.7610D+09	0.1414D-10	0.1715D+09
780.	0.7590D+09	0.2842D-10	0.1735D+09
790.	0.7570D+09	0.5608D-10	0.1755D+09
800.	0.7550D+09	0.1087D-09	0.1775D+09
810.	0.7530D+09	0.2071D-09	0.1795D+09
820.	0.7510D+09	0.3882D-09	0.1815D+09
830.	0.7490D+09	0.7162D-09	0.1835D+09
840.	0.7470D+09	0.1301D-08	0.1855D+09
850.	0.7451D+09	0.2329D-08	0.1874D+09
860.	0.7431D+09	0.4111D-08	0.1894D+09
870.	0.7412D+09	0.7157D-08	0.1913D+09
880.	0.7392D+09	0.1229D-07	0.1933D+09
890.	0.7372D+09	0.2085D-07	0.1953D+09
900.	0.7353D+09	0.3493D-07	0.1972D+09
910.	0.7334D+09	0.5783D-07	0.1991D+09
920.	0.7314D+09	0.9462D-07	0.2011D+09
930.	0.7295D+09	0.1531D-06	0.2030D+09
940.	0.7276D+09	0.2451D-06	0.2049D+09
950.	0.7257D+09	0.3882D-06	0.2068D+09
960.	0.7238D+09	0.6087D-06	0.2087D+09
970.	0.7218D+09	0.9449D-06	0.2107D+09
980.	0.7199D+09	0.1454D-05	0.2126D+09
990.	0.7180D+09	0.2213D-05	0.2145D+09
1000.	0.7161D+09	0.3352D-05	0.2164D+09

CRU-3 : PLANT 2/3 AREA PERCHED WATER

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.4881D+05	0.0000D+00	0.8136D+04
20.	0.4068D+05	0.0000D+00	0.1627D+05
30.	0.3254D+05	0.0000D+00	0.2441D+05
40.	0.2441D+05	0.0000D+00	0.3254D+05
50.	0.1627D+05	0.0000D+00	0.4068D+05
60.	0.8136D+04	0.0000D+00	0.4881D+05
70.	0.0000D+00	0.0000D+00	0.5695D+05
80.	0.0000D+00	0.1160-102	0.5695D+05
90.	0.0000D+00	0.4178D-91	0.5695D+05
100.	0.0000D+00	0.4590D-81	0.5695D+05
110.	0.0000D+00	0.7920D-73	0.5695D+05
120.	0.0000D+00	0.6059D-66	0.5695D+05
130.	0.0000D+00	0.4175D-60	0.5695D+05
140.	0.0000D+00	0.4310D-55	0.5695D+05
150.	0.0000D+00	0.9694D-51	0.5695D+05
160.	0.0000D+00	0.6300D-47	0.5695D+05
170.	0.0000D+00	0.1469D-43	0.5695D+05
180.	0.0000D+00	0.1455D-40	0.5695D+05
190.	0.0000D+00	0.7001D-38	0.5695D+05
200.	0.0000D+00	0.1821D-35	0.5695D+05
210.	0.0000D+00	0.2793D-33	0.5695D+05
220.	0.0000D+00	0.2714D-31	0.5695D+05
230.	0.0000D+00	0.1771D-29	0.5695D+05
240.	0.0000D+00	0.8161D-28	0.5695D+05
250.	0.0000D+00	0.2766D-26	0.5695D+05
260.	0.0000D+00	0.7142D-25	0.5695D+05
270.	0.0000D+00	0.1448D-23	0.5695D+05
280.	0.0000D+00	0.2365D-22	0.5695D+05
290.	0.0000D+00	0.3181D-21	0.5695D+05
300.	0.0000D+00	0.3594D-20	0.5695D+05
310.	0.0000D+00	0.3466D-19	0.5695D+05
320.	0.0000D+00	0.2897D-18	0.5695D+05

330.	0.0000D+00	0.2125D-17	0.5695D+05
340.	0.0000D+00	0.1384D-16	0.5695D+05
350.	0.0000D+00	0.8086D-16	0.5695D+05
360.	0.0000D+00	0.4275D-15	0.5695D+05
370.	0.0000D+00	0.2062D-14	0.5695D+05
380.	0.0000D+00	0.9143D-14	0.5695D+05
390.	0.0000D+00	0.3749D-13	0.5695D+05
400.	0.0000D+00	0.1430D-12	0.5695D+05
410.	0.0000D+00	0.5101D-12	0.5695D+05
420.	0.0000D+00	0.1710D-11	0.5695D+05
430.	0.0000D+00	0.5409D-11	0.5695D+05
440.	0.0000D+00	0.1621D-10	0.5695D+05
450.	0.0000D+00	0.4621D-10	0.5695D+05
460.	0.0000D+00	0.1256D-09	0.5695D+05
470.	0.0000D+00	0.3268D-09	0.5695D+05
480.	0.0000D+00	0.8157D-09	0.5695D+05
490.	0.0000D+00	0.1958D-08	0.5695D+05
500.	0.0000D+00	0.4533D-08	0.5695D+05
510.	0.0000D+00	0.1014D-07	0.5695D+05
520.	0.0000D+00	0.2194D-07	0.5695D+05
530.	0.0000D+00	0.4607D-07	0.5695D+05
540.	0.0000D+00	0.9397D-07	0.5695D+05
550.	0.0000D+00	0.1865D-06	0.5695D+05
560.	0.0000D+00	0.3606D-06	0.5695D+05
570.	0.0000D+00	0.6804D-06	0.5695D+05
580.	0.0000D+00	0.1255D-05	0.5695D+05
590.	0.0000D+00	0.2263D-05	0.5695D+05
600.	0.0000D+00	0.3997D-05	0.5695D+05
610.	0.0000D+00	0.6916D-05	0.5695D+05
620.	0.0000D+00	0.1174D-04	0.5695D+05
630.	0.0000D+00	0.1958D-04	0.5695D+05
640.	0.0000D+00	0.3207D-04	0.5695D+05
650.	0.0000D+00	0.5168D-04	0.5695D+05
660.	0.0000D+00	0.8198D-04	0.5695D+05
670.	0.0000D+00	0.1281D-03	0.5695D+05
680.	0.0000D+00	0.1972D-03	0.5695D+05
690.	0.0000D+00	0.2996D-03	0.5695D+05
700.	0.0000D+00	0.4490D-03	0.5695D+05
710.	0.0000D+00	0.6646D-03	0.5695D+05
720.	0.0000D+00	0.9717D-03	0.5695D+05
730.	0.0000D+00	0.1404D-02	0.5695D+05
740.	0.0000D+00	0.2007D-02	0.5695D+05
750.	0.0000D+00	0.2838D-02	0.5695D+05
760.	0.0000D+00	0.3971D-02	0.5695D+05
770.	0.0000D+00	0.5502D-02	0.5695D+05
780.	0.0000D+00	0.7552D-02	0.5695D+05
790.	0.0000D+00	0.1027D-01	0.5695D+05
800.	0.0000D+00	0.1385D-01	0.5695D+05
810.	0.0000D+00	0.1851D-01	0.5695D+05
820.	0.0000D+00	0.2454D-01	0.5695D+05
830.	0.0000D+00	0.3228D-01	0.5695D+05
840.	0.0000D+00	0.4215D-01	0.5695D+05
850.	0.0000D+00	0.5464D-01	0.5695D+05
860.	0.0000D+00	0.7032D-01	0.5695D+05
870.	0.0000D+00	0.8990D-01	0.5695D+05
880.	0.0000D+00	0.1142D+00	0.5695D+05
890.	0.0000D+00	0.1441D+00	0.5695D+05
900.	0.0000D+00	0.1808D+00	0.5695D+05
910.	0.0000D+00	0.2255D+00	0.5695D+05
920.	0.0000D+00	0.2797D+00	0.5695D+05
930.	0.0000D+00	0.3449D+00	0.5695D+05
940.	0.0000D+00	0.4231D+00	0.5695D+05
950.	0.0000D+00	0.5165D+00	0.5695D+05
960.	0.0000D+00	0.6273D+00	0.5695D+05
970.	0.0000D+00	0.7583D+00	0.5695D+05

980.	0.0000D+00	0.9124D+00	0.5695D+05
990.	0.0000D+00	0.1093D+01	0.5695D+05
1000.	0.0000D+00	0.1304D+01	0.5695D+05

CRU-3 : PLANT 6 AREA

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.4650D+09	0.0000D+00	0.1229D+07
20.	0.4637D+09	0.0000D+00	0.2455D+07
30.	0.4625D+09	0.0000D+00	0.3678D+07
40.	0.4613D+09	0.0000D+00	0.4897D+07
50.	0.4601D+09	0.0000D+00	0.6114D+07
60.	0.4589D+09	0.0000D+00	0.7327D+07
70.	0.4577D+09	0.0000D+00	0.8537D+07
80.	0.4565D+09	0.0000D+00	0.9743D+07
90.	0.4553D+09	0.0000D+00	0.1095D+08
100.	0.4541D+09	0.0000D+00	0.1215D+08
110.	0.4529D+09	0.0000D+00	0.1334D+08
120.	0.4517D+09	0.0000D+00	0.1454D+08
130.	0.4505D+09	0.0000D+00	0.1573D+08
140.	0.4493D+09	0.0000D+00	0.1692D+08
150.	0.4481D+09	0.1342-102	0.1810D+08
160.	0.4469D+09	0.1610D-95	0.1928D+08
170.	0.4457D+09	0.5870D-89	0.2046D+08
180.	0.4446D+09	0.4402D-83	0.2164D+08
190.	0.4434D+09	0.7979D-78	0.2281D+08
200.	0.4422D+09	0.4356D-73	0.2398D+08
210.	0.4411D+09	0.8487D-69	0.2514D+08
220.	0.4399D+09	0.6783D-65	0.2631D+08
230.	0.4387D+09	0.2495D-61	0.2747D+08
240.	0.4376D+09	0.4646D-58	0.2862D+08
250.	0.4364D+09	0.4751D-55	0.2978D+08
260.	0.4353D+09	0.2856D-52	0.3093D+08
270.	0.4341D+09	0.1070D-49	0.3208D+08
280.	0.4330D+09	0.2628D-47	0.3322D+08
290.	0.4318D+09	0.4416D-45	0.3436D+08
300.	0.4307D+09	0.5271D-43	0.3550D+08
310.	0.4296D+09	0.4618D-41	0.3664D+08
320.	0.4284D+09	0.3057D-39	0.3777D+08
330.	0.4273D+09	0.1568D-37	0.3890D+08
340.	0.4262D+09	0.6368D-36	0.4002D+08
350.	0.4251D+09	0.2090D-34	0.4115D+08
360.	0.4239D+09	0.5643D-33	0.4227D+08
370.	0.4228D+09	0.1273D-31	0.4339D+08
380.	0.4217D+09	0.2431D-30	0.4450D+08
390.	0.4206D+09	0.3985D-29	0.4561D+08
400.	0.4195D+09	0.5669D-28	0.4672D+08
410.	0.4184D+09	0.7070D-27	0.4783D+08
420.	0.4173D+09	0.7804D-26	0.4893D+08
430.	0.4162D+09	0.7688D-25	0.5003D+08
440.	0.4151D+09	0.6811D-24	0.5113D+08
450.	0.4140D+09	0.5465D-23	0.5222D+08
460.	0.4129D+09	0.3997D-22	0.5331D+08
470.	0.4118D+09	0.2681D-21	0.5440D+08
480.	0.4107D+09	0.1657D-20	0.5549D+08
490.	0.4096D+09	0.9491D-20	0.5657D+08
500.	0.4085D+09	0.5059D-19	0.5765D+08
510.	0.4075D+09	0.2520D-18	0.5873D+08
520.	0.4064D+09	0.1178D-17	0.5980D+08
530.	0.4053D+09	0.5181D-17	0.6087D+08

540.	0.4043D+09	0.2154D-16	0.6194D+08
550.	0.4032D+09	0.8482D-16	0.6301D+08
560.	0.4021D+09	0.3175D-15	0.6407D+08
570.	0.4011D+09	0.1132D-14	0.6513D+08
580.	0.4000D+09	0.3858D-14	0.6619D+08
590.	0.3990D+09	0.1259D-13	0.6724D+08
600.	0.3979D+09	0.3939D-13	0.6830D+08
610.	0.3969D+09	0.1185D-12	0.6935D+08
620.	0.3958D+09	0.3437D-12	0.7039D+08
630.	0.3948D+09	0.9614D-12	0.7144D+08
640.	0.3937D+09	0.2600D-11	0.7248D+08
650.	0.3927D+09	0.6805D-11	0.7351D+08
660.	0.3916D+09	0.1727D-10	0.7455D+08
670.	0.3906D+09	0.4256D-10	0.7558D+08
680.	0.3896D+09	0.1020D-09	0.7661D+08
690.	0.3886D+09	0.2377D-09	0.7764D+08
700.	0.3875D+09	0.5402D-09	0.7866D+08
710.	0.3865D+09	0.1197D-08	0.7969D+08
720.	0.3855D+09	0.2592D-08	0.8071D+08
730.	0.3845D+09	0.5483D-08	0.8172D+08
740.	0.3835D+09	0.1135D-07	0.8274D+08
750.	0.3825D+09	0.2302D-07	0.8375D+08
760.	0.3814D+09	0.4576D-07	0.8475D+08
770.	0.3804D+09	0.8919D-07	0.8576D+08
780.	0.3794D+09	0.1706D-06	0.8676D+08
790.	0.3784D+09	0.3206D-06	0.8776D+08
800.	0.3774D+09	0.5920D-06	0.8876D+08
810.	0.3764D+09	0.1075D-05	0.8976D+08
820.	0.3755D+09	0.1922D-05	0.9075D+08
830.	0.3745D+09	0.3383D-05	0.9174D+08
840.	0.3735D+09	0.5868D-05	0.9273D+08
850.	0.3725D+09	0.1003D-04	0.9371D+08
860.	0.3715D+09	0.1692D-04	0.9469D+08
870.	0.3705D+09	0.2815D-04	0.9567D+08
880.	0.3696D+09	0.4625D-04	0.9665D+08
890.	0.3686D+09	0.7503D-04	0.9762D+08
900.	0.3676D+09	0.1203D-03	0.9860D+08
910.	0.3666D+09	0.1906D-03	0.9957D+08
920.	0.3657D+09	0.2987D-03	0.1005D+09
930.	0.3647D+09	0.4629D-03	0.1015D+09
940.	0.3637D+09	0.7101D-03	0.1025D+09
950.	0.3628D+09	0.1078D-02	0.1034D+09
960.	0.3618D+09	0.1621D-02	0.1044D+09
970.	0.3609D+09	0.2414D-02	0.1053D+09
980.	0.3599D+09	0.3563D-02	0.1063D+09
990.	0.3590D+09	0.5207D-02	0.1072D+09
1000.	0.3580D+09	0.7565D-02	0.1082D+09

CRU-3 : PLANT 6 AREA PERCHED WATER

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.2440D+05	0.0000D+00	0.4067D+04
20.	0.2034D+05	0.0000D+00	0.8134D+04
30.	0.1627D+05	0.0000D+00	0.1220D+05
40.	0.1220D+05	0.0000D+00	0.1627D+05
50.	0.8134D+04	0.0000D+00	0.2034D+05
60.	0.4067D+04	0.0000D+00	0.2440D+05
70.	0.0000D+00	0.0000D+00	0.2847D+05
80.	0.0000D+00	0.0000D+00	0.2847D+05
90.	0.0000D+00	0.0000D+00	0.2847D+05

100.	0.0000D+00	0.0000D+00	0.2847D+05
110.	0.0000D+00	0.3088D-87	0.2847D+05
120.	0.0000D+00	0.3852D-78	0.2847D+05
130.	0.0000D+00	0.6744D-71	0.2847D+05
140.	0.0000D+00	0.7176D-65	0.2847D+05
150.	0.0000D+00	0.1200D-59	0.2847D+05
160.	0.0000D+00	0.4541D-55	0.2847D+05
170.	0.0000D+00	0.5038D-51	0.2847D+05
180.	0.0000D+00	0.2004D-47	0.2847D+05
190.	0.0000D+00	0.3354D-44	0.2847D+05
200.	0.0000D+00	0.2684D-41	0.2847D+05
210.	0.0000D+00	0.1139D-38	0.2847D+05
220.	0.0000D+00	0.2794D-36	0.2847D+05
230.	0.0000D+00	0.4248D-34	0.2847D+05
240.	0.0000D+00	0.4246D-32	0.2847D+05
250.	0.0000D+00	0.2934D-30	0.2847D+05
260.	0.0000D+00	0.1461D-28	0.2847D+05
270.	0.0000D+00	0.5433D-27	0.2847D+05
280.	0.0000D+00	0.1557D-25	0.2847D+05
290.	0.0000D+00	0.3532D-24	0.2847D+05
300.	0.0000D+00	0.6486D-23	0.2847D+05
310.	0.0000D+00	0.9842D-22	0.2847D+05
320.	0.0000D+00	0.1256D-20	0.2847D+05
330.	0.0000D+00	0.1369D-19	0.2847D+05
340.	0.0000D+00	0.1293D-18	0.2847D+05
350.	0.0000D+00	0.1070D-17	0.2847D+05
360.	0.0000D+00	0.7852D-17	0.2847D+05
370.	0.0000D+00	0.5154D-16	0.2847D+05
380.	0.0000D+00	0.3054D-15	0.2847D+05
390.	0.0000D+00	0.1647D-14	0.2847D+05
400.	0.0000D+00	0.8132D-14	0.2847D+05
410.	0.0000D+00	0.3703D-13	0.2847D+05
420.	0.0000D+00	0.1564D-12	0.2847D+05
430.	0.0000D+00	0.6155D-12	0.2847D+05
440.	0.0000D+00	0.2269D-11	0.2847D+05
450.	0.0000D+00	0.7870D-11	0.2847D+05
460.	0.0000D+00	0.2578D-10	0.2847D+05
470.	0.0000D+00	0.8002D-10	0.2847D+05
480.	0.0000D+00	0.2362D-09	0.2847D+05
490.	0.0000D+00	0.6652D-09	0.2847D+05
500.	0.0000D+00	0.1792D-08	0.2847D+05
510.	0.0000D+00	0.4630D-08	0.2847D+05
520.	0.0000D+00	0.1150D-07	0.2847D+05
530.	0.0000D+00	0.2752D-07	0.2847D+05
540.	0.0000D+00	0.6357D-07	0.2847D+05
550.	0.0000D+00	0.1421D-06	0.2847D+05
560.	0.0000D+00	0.3077D-06	0.2847D+05
570.	0.0000D+00	0.6466D-06	0.2847D+05
580.	0.0000D+00	0.1321D-05	0.2847D+05
590.	0.0000D+00	0.2627D-05	0.2847D+05
600.	0.0000D+00	0.5093D-05	0.2847D+05
610.	0.0000D+00	0.9636D-05	0.2847D+05
620.	0.0000D+00	0.1782D-04	0.2847D+05
630.	0.0000D+00	0.3224D-04	0.2847D+05
640.	0.0000D+00	0.5708D-04	0.2847D+05
650.	0.0000D+00	0.9904D-04	0.2847D+05
660.	0.0000D+00	0.1686D-03	0.2847D+05
670.	0.0000D+00	0.2816D-03	0.2847D+05
680.	0.0000D+00	0.4624D-03	0.2847D+05
690.	0.0000D+00	0.7465D-03	0.2847D+05
700.	0.0000D+00	0.1186D-02	0.2847D+05
710.	0.0000D+00	0.1855D-02	0.2847D+05
720.	0.0000D+00	0.2859D-02	0.2847D+05
730.	0.0000D+00	0.4344D-02	0.2847D+05
740.	0.0000D+00	0.6510D-02	0.2847D+05

750.	0.0000D+00	0.9632D-02	0.2847D+05
760.	0.0000D+00	0.1407D-01	0.2847D+05
770.	0.0000D+00	0.2031D-01	0.2847D+05
780.	0.0000D+00	0.2898D-01	0.2847D+05
790.	0.0000D+00	0.4088D-01	0.2847D+05
800.	0.0000D+00	0.5706D-01	0.2847D+05
810.	0.0000D+00	0.7883D-01	0.2847D+05
820.	0.0000D+00	0.1078D+00	0.2847D+05
830.	0.0000D+00	0.1461D+00	0.2847D+05
840.	0.0000D+00	0.1961D+00	0.2847D+05
850.	0.0000D+00	0.2608D+00	0.2847D+05
860.	0.0000D+00	0.3440D+00	0.2847D+05
870.	0.0000D+00	0.4500D+00	0.2847D+05
880.	0.0000D+00	0.5840D+00	0.2847D+05
890.	0.0000D+00	0.7521D+00	0.2847D+05
900.	0.0000D+00	0.9614D+00	0.2847D+05
910.	0.0000D+00	0.1220D+01	0.2847D+05
920.	0.0000D+00	0.1538D+01	0.2847D+05
930.	0.0000D+00	0.1925D+01	0.2847D+05
940.	0.0000D+00	0.2395D+01	0.2847D+05
950.	0.0000D+00	0.2961D+01	0.2847D+05
960.	0.0000D+00	0.3638D+01	0.2847D+05
970.	0.0000D+00	0.4444D+01	0.2847D+05
980.	0.0000D+00	0.5399D+01	0.2846D+05
990.	0.0000D+00	0.6522D+01	0.2846D+05
1000.	0.0000D+00	0.7839D+01	0.2846D+05

CRU-3 : PLANT 9 AREA

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.4650D+09	0.0000D+00	0.1229D+07
20.	0.4637D+09	0.0000D+00	0.2455D+07
30.	0.4625D+09	0.0000D+00	0.3678D+07
40.	0.4613D+09	0.0000D+00	0.4897D+07
50.	0.4601D+09	0.0000D+00	0.6114D+07
60.	0.4589D+09	0.0000D+00	0.7327D+07
70.	0.4577D+09	0.0000D+00	0.8537D+07
80.	0.4565D+09	0.0000D+00	0.9743D+07
90.	0.4553D+09	0.0000D+00	0.1095D+08
100.	0.4541D+09	0.0000D+00	0.1215D+08
110.	0.4529D+09	0.0000D+00	0.1334D+08
120.	0.4517D+09	0.0000D+00	0.1454D+08
130.	0.4505D+09	0.0000D+00	0.1573D+08
140.	0.4493D+09	0.0000D+00	0.1692D+08
150.	0.4481D+09	0.0000D+00	0.1810D+08
160.	0.4469D+09	0.0000D+00	0.1928D+08
170.	0.4457D+09	0.0000D+00	0.2046D+08
180.	0.4446D+09	0.0000D+00	0.2164D+08
190.	0.4434D+09	0.0000D+00	0.2281D+08
200.	0.4422D+09	0.2175D-99	0.2398D+08
210.	0.4411D+09	0.6768D-94	0.2514D+08
220.	0.4399D+09	0.1725D-88	0.2631D+08
230.	0.4387D+09	0.8701D-84	0.2747D+08
240.	0.4376D+09	0.1450D-79	0.2862D+08
250.	0.4364D+09	0.1053D-75	0.2978D+08
260.	0.4353D+09	0.3824D-72	0.3093D+08
270.	0.4341D+09	0.7566D-69	0.3208D+08
280.	0.4330D+09	0.8705D-66	0.3322D+08
290.	0.4318D+09	0.6159D-63	0.3436D+08
300.	0.4307D+09	0.2813D-60	0.3550D+08

310.	0.4296D+09	0.8647D-58	0.3664D+08
320.	0.4284D+09	0.1856D-55	0.3777D+08
330.	0.4273D+09	0.2875D-53	0.3890D+08
340.	0.4262D+09	0.3307D-51	0.4002D+08
350.	0.4251D+09	0.2895D-49	0.4115D+08
360.	0.4239D+09	0.1975D-47	0.4227D+08
370.	0.4228D+09	0.1070D-45	0.4339D+08
380.	0.4217D+09	0.4694D-44	0.4450D+08
390.	0.4206D+09	0.1693D-42	0.4561D+08
400.	0.4195D+09	0.5096D-41	0.4672D+08
410.	0.4184D+09	0.1297D-39	0.4783D+08
420.	0.4173D+09	0.2824D-38	0.4893D+08
430.	0.4162D+09	0.5320D-37	0.5003D+08
440.	0.4151D+09	0.8753D-36	0.5113D+08
450.	0.4140D+09	0.1269D-34	0.5222D+08
460.	0.4129D+09	0.1636D-33	0.5331D+08
470.	0.4118D+09	0.1888D-32	0.5440D+08
480.	0.4107D+09	0.1964D-31	0.5549D+08
490.	0.4096D+09	0.1854D-30	0.5657D+08
500.	0.4085D+09	0.1597D-29	0.5765D+08
510.	0.4075D+09	0.1262D-28	0.5873D+08
520.	0.4064D+09	0.9190D-28	0.5980D+08
530.	0.4053D+09	0.6201D-27	0.6087D+08
540.	0.4043D+09	0.3892D-26	0.6194D+08
550.	0.4032D+09	0.2281D-25	0.6301D+08
560.	0.4021D+09	0.1253D-24	0.6407D+08
570.	0.4011D+09	0.6474D-24	0.6513D+08
580.	0.4000D+09	0.3155D-23	0.6619D+08
590.	0.3990D+09	0.1455D-22	0.6724D+08
600.	0.3979D+09	0.6368D-22	0.6830D+08
610.	0.3969D+09	0.2651D-21	0.6935D+08
620.	0.3958D+09	0.1052D-20	0.7039D+08
630.	0.3948D+09	0.3991D-20	0.7144D+08
640.	0.3937D+09	0.1450D-19	0.7248D+08
650.	0.3927D+09	0.5056D-19	0.7351D+08
660.	0.3916D+09	0.1695D-18	0.7455D+08
670.	0.3906D+09	0.5473D-18	0.7558D+08
680.	0.3896D+09	0.1705D-17	0.7661D+08
690.	0.3886D+09	0.5132D-17	0.7764D+08
700.	0.3875D+09	0.1495D-16	0.7866D+08
710.	0.3865D+09	0.4219D-16	0.7969D+08
720.	0.3855D+09	0.1155D-15	0.8071D+08
730.	0.3845D+09	0.3074D-15	0.8172D+08
740.	0.3835D+09	0.7955D-15	0.8274D+08
750.	0.3825D+09	0.2005D-14	0.8375D+08
760.	0.3814D+09	0.4924D-14	0.8475D+08
770.	0.3804D+09	0.1180D-13	0.8576D+08
780.	0.3794D+09	0.2762D-13	0.8676D+08
790.	0.3784D+09	0.6320D-13	0.8776D+08
800.	0.3774D+09	0.1415D-12	0.8876D+08
810.	0.3764D+09	0.3103D-12	0.8976D+08
820.	0.3755D+09	0.6667D-12	0.9075D+08
830.	0.3745D+09	0.1405D-11	0.9174D+08
840.	0.3735D+09	0.2903D-11	0.9273D+08
850.	0.3725D+09	0.5893D-11	0.9371D+08
860.	0.3715D+09	0.1175D-10	0.9469D+08
870.	0.3705D+09	0.2305D-10	0.9567D+08
880.	0.3696D+09	0.4447D-10	0.9665D+08
890.	0.3686D+09	0.8444D-10	0.9762D+08
900.	0.3676D+09	0.1579D-09	0.9860D+08
910.	0.3666D+09	0.2910D-09	0.9957D+08
920.	0.3657D+09	0.5287D-09	0.1005D+09
930.	0.3647D+09	0.9472D-09	0.1015D+09
940.	0.3637D+09	0.1675D-08	0.1025D+09
950.	0.3628D+09	0.2923D-08	0.1034D+09

960.	0.3618D+09	0.5039D-08	0.1044D+09
970.	0.3609D+09	0.8576D-08	0.1053D+09
980.	0.3599D+09	0.1445D-07	0.1063D+09
990.	0.3590D+09	0.2398D-07	0.1072D+09
1000.	0.3580D+09	0.3968D-07	0.1082D+09

CRU-3 : PLANT 9 AREA PERCHED WATER

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.2440D+05	0.0000D+00	0.4067D+04
20.	0.2034D+05	0.0000D+00	0.8135D+04
30.	0.1627D+05	0.0000D+00	0.1220D+05
40.	0.1220D+05	0.0000D+00	0.1627D+05
50.	0.8135D+04	0.0000D+00	0.2034D+05
60.	0.4067D+04	0.0000D+00	0.2440D+05
70.	0.0000D+00	0.0000D+00	0.2847D+05
80.	0.0000D+00	0.0000D+00	0.2847D+05
90.	0.0000D+00	0.0000D+00	0.2847D+05
100.	0.0000D+00	0.0000D+00	0.2847D+05
110.	0.0000D+00	0.7870-106	0.2847D+05
120.	0.0000D+00	0.1519D-93	0.2847D+05
130.	0.0000D+00	0.1302D-84	0.2847D+05
140.	0.0000D+00	0.1395D-77	0.2847D+05
150.	0.0000D+00	0.1518D-71	0.2847D+05
160.	0.0000D+00	0.2927D-66	0.2847D+05
170.	0.0000D+00	0.1361D-61	0.2847D+05
180.	0.0000D+00	0.1929D-57	0.2847D+05
190.	0.0000D+00	0.1004D-53	0.2847D+05
200.	0.0000D+00	0.2225D-50	0.2847D+05
210.	0.0000D+00	0.2370D-47	0.2847D+05
220.	0.0000D+00	0.1340D-44	0.2847D+05
230.	0.0000D+00	0.4366D-42	0.2847D+05
240.	0.0000D+00	0.8772D-40	0.2847D+05
250.	0.0000D+00	0.1152D-37	0.2847D+05
260.	0.0000D+00	0.1037D-35	0.2847D+05
270.	0.0000D+00	0.6680D-34	0.2847D+05
280.	0.0000D+00	0.3189D-32	0.2847D+05
290.	0.0000D+00	0.1163D-30	0.2847D+05
300.	0.0000D+00	0.3332D-29	0.2847D+05
310.	0.0000D+00	0.7666D-28	0.2847D+05
320.	0.0000D+00	0.1446D-26	0.2847D+05
330.	0.0000D+00	0.2278D-25	0.2847D+05
340.	0.0000D+00	0.3044D-24	0.2847D+05
350.	0.0000D+00	0.3498D-23	0.2847D+05
360.	0.0000D+00	0.3501D-22	0.2847D+05
370.	0.0000D+00	0.3086D-21	0.2847D+05
380.	0.0000D+00	0.2420D-20	0.2847D+05
390.	0.0000D+00	0.1703D-19	0.2847D+05
400.	0.0000D+00	0.1085D-18	0.2847D+05
410.	0.0000D+00	0.6295D-18	0.2847D+05
420.	0.0000D+00	0.3352D-17	0.2847D+05
430.	0.0000D+00	0.1648D-16	0.2847D+05
440.	0.0000D+00	0.7514D-16	0.2847D+05
450.	0.0000D+00	0.3196D-15	0.2847D+05
460.	0.0000D+00	0.1274D-14	0.2847D+05
470.	0.0000D+00	0.4774D-14	0.2847D+05
480.	0.0000D+00	0.1690D-13	0.2847D+05
490.	0.0000D+00	0.5669D-13	0.2847D+05
500.	0.0000D+00	0.1808D-12	0.2847D+05
510.	0.0000D+00	0.5497D-12	0.2847D+05

520.	0.0000D+00	0.1598D-11	0.2847D+05
530.	0.0000D+00	0.4453D-11	0.2847D+05
540.	0.0000D+00	0.1192D-10	0.2847D+05
550.	0.0000D+00	0.3073D-10	0.2847D+05
560.	0.0000D+00	0.7643D-10	0.2847D+05
570.	0.0000D+00	0.1837D-09	0.2847D+05
580.	0.0000D+00	0.4277D-09	0.2847D+05
590.	0.0000D+00	0.9656D-09	0.2847D+05
600.	0.0000D+00	0.2118D-08	0.2847D+05
610.	0.0000D+00	0.4517D-08	0.2847D+05
620.	0.0000D+00	0.9385D-08	0.2847D+05
630.	0.0000D+00	0.1902D-07	0.2847D+05
640.	0.0000D+00	0.3762D-07	0.2847D+05
650.	0.0000D+00	0.7274D-07	0.2847D+05
660.	0.0000D+00	0.1377D-06	0.2847D+05
670.	0.0000D+00	0.2552D-06	0.2847D+05
680.	0.0000D+00	0.4636D-06	0.2847D+05
690.	0.0000D+00	0.8263D-06	0.2847D+05
700.	0.0000D+00	0.1446D-05	0.2847D+05
710.	0.0000D+00	0.2486D-05	0.2847D+05
720.	0.0000D+00	0.4203D-05	0.2847D+05
730.	0.0000D+00	0.6992D-05	0.2847D+05
740.	0.0000D+00	0.1145D-04	0.2847D+05
750.	0.0000D+00	0.1848D-04	0.2847D+05
760.	0.0000D+00	0.2941D-04	0.2847D+05
770.	0.0000D+00	0.4615D-04	0.2847D+05
780.	0.0000D+00	0.7148D-04	0.2847D+05
790.	0.0000D+00	0.1093D-03	0.2847D+05
800.	0.0000D+00	0.1651D-03	0.2847D+05
810.	0.0000D+00	0.2465D-03	0.2847D+05
820.	0.0000D+00	0.3639D-03	0.2847D+05
830.	0.0000D+00	0.5314D-03	0.2847D+05
840.	0.0000D+00	0.7677D-03	0.2847D+05
850.	0.0000D+00	0.1098D-02	0.2847D+05
860.	0.0000D+00	0.1555D-02	0.2847D+05
870.	0.0000D+00	0.2181D-02	0.2847D+05
880.	0.0000D+00	0.3032D-02	0.2847D+05
890.	0.0000D+00	0.4177D-02	0.2847D+05
900.	0.0000D+00	0.5706D-02	0.2847D+05
910.	0.0000D+00	0.7731D-02	0.2847D+05
920.	0.0000D+00	0.1039D-01	0.2847D+05
930.	0.0000D+00	0.1386D-01	0.2847D+05
940.	0.0000D+00	0.1835D-01	0.2847D+05
950.	0.0000D+00	0.2411D-01	0.2847D+05
960.	0.0000D+00	0.3147D-01	0.2847D+05
970.	0.0000D+00	0.4080D-01	0.2847D+05
980.	0.0000D+00	0.5254D-01	0.2847D+05
990.	0.0000D+00	0.6723D-01	0.2847D+05
1000.	0.0000D+00	0.8555D-01	0.2847D+05

CRU-3 : OTHER MAIN PLANT BUILDINGS

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.4378D+10	0.0000D+00	0.2457D+08
20.	0.4354D+10	0.0000D+00	0.4901D+08
30.	0.4330D+10	0.0000D+00	0.7331D+08
40.	0.4306D+10	0.0000D+00	0.9747D+08
50.	0.4281D+10	0.0000D+00	0.1215D+09
60.	0.4258D+10	0.0000D+00	0.1454D+09
70.	0.4234D+10	0.0000D+00	0.1692D+09

80.	0.4210D+10	0.0000D+00	0.1928D+09
90.	0.4187D+10	0.0000D+00	0.2163D+09
100.	0.4163D+10	0.0000D+00	0.2396D+09
110.	0.4140D+10	0.0000D+00	0.2629D+09
120.	0.4117D+10	0.0000D+00	0.2860D+09
130.	0.4094D+10	0.0000D+00	0.3090D+09
140.	0.4071D+10	0.0000D+00	0.3318D+09
150.	0.4048D+10	0.0000D+00	0.3545D+09
160.	0.4026D+10	0.0000D+00	0.3771D+09
170.	0.4003D+10	0.0000D+00	0.3996D+09
180.	0.3981D+10	0.0000D+00	0.4219D+09
190.	0.3959D+10	0.0000D+00	0.4442D+09
200.	0.3937D+10	0.0000D+00	0.4663D+09
210.	0.3915D+10	0.0000D+00	0.4882D+09
220.	0.3893D+10	0.0000D+00	0.5101D+09
230.	0.3871D+10	0.0000D+00	0.5318D+09
240.	0.3850D+10	0.0000D+00	0.5534D+09
250.	0.3828D+10	0.0000D+00	0.5749D+09
260.	0.3807D+10	0.0000D+00	0.5963D+09
270.	0.3786D+10	0.0000D+00	0.6175D+09
280.	0.3764D+10	0.0000D+00	0.6386D+09
290.	0.3743D+10	0.0000D+00	0.6596D+09
300.	0.3722D+10	0.0000D+00	0.6805D+09
310.	0.3702D+10	0.0000D+00	0.7013D+09
320.	0.3681D+10	0.0000D+00	0.7220D+09
330.	0.3661D+10	0.0000D+00	0.7425D+09
340.	0.3640D+10	0.0000D+00	0.7629D+09
350.	0.3620D+10	0.0000D+00	0.7832D+09
360.	0.3600D+10	0.0000D+00	0.8034D+09
370.	0.3579D+10	0.0000D+00	0.8235D+09
380.	0.3559D+10	0.0000D+00	0.8435D+09
390.	0.3540D+10	0.0000D+00	0.8634D+09
400.	0.3520D+10	0.0000D+00	0.8831D+09
410.	0.3500D+10	0.0000D+00	0.9028D+09
420.	0.3481D+10	0.0000D+00	0.9223D+09
430.	0.3461D+10	0.0000D+00	0.9417D+09
440.	0.3442D+10	0.0000D+00	0.9611D+09
450.	0.3423D+10	0.0000D+00	0.9803D+09
460.	0.3404D+10	0.0000D+00	0.9994D+09
470.	0.3385D+10	0.0000D+00	0.1018D+10
480.	0.3366D+10	0.0000D+00	0.1037D+10
490.	0.3347D+10	0.0000D+00	0.1056D+10
500.	0.3328D+10	0.0000D+00	0.1075D+10
510.	0.3310D+10	0.0000D+00	0.1093D+10
520.	0.3291D+10	0.7799D-79	0.1112D+10
530.	0.3273D+10	0.7718D-63	0.1130D+10
540.	0.3255D+10	0.1138D-55	0.1148D+10
550.	0.3236D+10	0.1102D-52	0.1167D+10
560.	0.3218D+10	0.1989D-50	0.1185D+10
570.	0.3200D+10	0.7084D-49	0.1203D+10
580.	0.3183D+10	0.1356D-47	0.1220D+10
590.	0.3165D+10	0.2065D-46	0.1238D+10
600.	0.3147D+10	0.2789D-45	0.1256D+10
610.	0.3130D+10	0.3431D-44	0.1273D+10
620.	0.3112D+10	0.3875D-43	0.1291D+10
630.	0.3095D+10	0.4039D-42	0.1308D+10
640.	0.3077D+10	0.3900D-41	0.1326D+10
650.	0.3060D+10	0.3502D-40	0.1343D+10
660.	0.3043D+10	0.2934D-39	0.1360D+10
670.	0.3026D+10	0.2302D-38	0.1377D+10
680.	0.3009D+10	0.1695D-37	0.1394D+10
690.	0.2993D+10	0.1176D-36	0.1410D+10
700.	0.2976D+10	0.7699D-36	0.1427D+10
710.	0.2959D+10	0.4772D-35	0.1444D+10
720.	0.2943D+10	0.2807D-34	0.1460D+10

730.	0.2926D+10	0.1570D-33	0.1477D+10
740.	0.2910D+10	0.8365D-33	0.1493D+10
750.	0.2894D+10	0.4257D-32	0.1509D+10
760.	0.2878D+10	0.2072D-31	0.1525D+10
770.	0.2862D+10	0.9666D-31	0.1541D+10
780.	0.2846D+10	0.4328D-30	0.1557D+10
790.	0.2830D+10	0.1863D-29	0.1573D+10
800.	0.2814D+10	0.7722D-29	0.1589D+10
810.	0.2798D+10	0.3086D-28	0.1605D+10
820.	0.2783D+10	0.1191D-27	0.1620D+10
830.	0.2767D+10	0.4442D-27	0.1636D+10
840.	0.2752D+10	0.1604D-26	0.1651D+10
850.	0.2736D+10	0.5611D-26	0.1667D+10
860.	0.2721D+10	0.1905D-25	0.1682D+10
870.	0.2706D+10	0.6278D-25	0.1697D+10
880.	0.2691D+10	0.2013D-24	0.1712D+10
890.	0.2676D+10	0.6273D-24	0.1727D+10
900.	0.2661D+10	0.1908D-23	0.1742D+10
910.	0.2646D+10	0.5638D-23	0.1757D+10
920.	0.2631D+10	0.1632D-22	0.1772D+10
930.	0.2616D+10	0.4588D-22	0.1787D+10
940.	0.2602D+10	0.1269D-21	0.1801D+10
950.	0.2587D+10	0.3401D-21	0.1816D+10
960.	0.2573D+10	0.9028D-21	0.1830D+10
970.	0.2558D+10	0.2307D-20	0.1845D+10
980.	0.2544D+10	0.5922D-20	0.1859D+10
990.	0.2530D+10	0.1436D-19	0.1873D+10
1000.	0.2516D+10	0.3613D-19	0.1887D+10

CRU-3 : OTHER MAIN PLANT BUILDINGS PERCHED WATER

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.9669D+06	0.0000D+00	0.1611D+06
20.	0.8057D+06	0.0000D+00	0.3223D+06
30.	0.6446D+06	0.0000D+00	0.4834D+06
40.	0.4834D+06	0.0000D+00	0.6446D+06
50.	0.3223D+06	0.0000D+00	0.8057D+06
60.	0.1611D+06	0.0000D+00	0.9669D+06
70.	0.0000D+00	0.0000D+00	0.1128D+07
80.	0.0000D+00	0.0000D+00	0.1128D+07
90.	0.0000D+00	0.0000D+00	0.1128D+07
100.	0.0000D+00	0.0000D+00	0.1128D+07
110.	0.0000D+00	0.0000D+00	0.1128D+07
120.	0.0000D+00	0.0000D+00	0.1128D+07
130.	0.0000D+00	0.0000D+00	0.1128D+07
140.	0.0000D+00	0.0000D+00	0.1128D+07
150.	0.0000D+00	0.0000D+00	0.1128D+07
160.	0.0000D+00	0.1622D-74	0.1128D+07
170.	0.0000D+00	0.3014D-63	0.1128D+07
180.	0.0000D+00	0.9213D-57	0.1128D+07
190.	0.0000D+00	0.1819D-52	0.1128D+07
200.	0.0000D+00	0.7268D-49	0.1128D+07
210.	0.0000D+00	0.1189D-45	0.1128D+07
220.	0.0000D+00	0.9377D-43	0.1128D+07
230.	0.0000D+00	0.3935D-40	0.1128D+07
240.	0.0000D+00	0.9542D-38	0.1128D+07
250.	0.0000D+00	0.1433D-35	0.1128D+07
260.	0.0000D+00	0.1413D-33	0.1128D+07
270.	0.0000D+00	0.9604D-32	0.1128D+07
280.	0.0000D+00	0.4698D-30	0.1128D+07

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290.	0.0000D+00	0.1715D-28	0.1128D+07
300.	0.0000D+00	0.4821D-27	0.1128D+07
310.	0.0000D+00	0.1072D-25	0.1128D+07
320.	0.0000D+00	0.1932D-24	0.1128D+07
330.	0.0000D+00	0.2881D-23	0.1128D+07
340.	0.0000D+00	0.3618D-22	0.1128D+07
350.	0.0000D+00	0.3891D-21	0.1128D+07
360.	0.0000D+00	0.3633D-20	0.1128D+07
370.	0.0000D+00	0.2983D-19	0.1128D+07
380.	0.0000D+00	0.2177D-18	0.1128D+07
390.	0.0000D+00	0.1426D-17	0.1128D+07
400.	0.0000D+00	0.8459D-17	0.1128D+07
410.	0.0000D+00	0.4579D-16	0.1128D+07
420.	0.0000D+00	0.2277D-15	0.1128D+07
430.	0.0000D+00	0.1047D-14	0.1128D+07
440.	0.0000D+00	0.4475D-14	0.1128D+07
450.	0.0000D+00	0.1787D-13	0.1128D+07
460.	0.0000D+00	0.6696D-13	0.1128D+07
470.	0.0000D+00	0.2364D-12	0.1128D+07
480.	0.0000D+00	0.7896D-12	0.1128D+07
490.	0.0000D+00	0.2503D-11	0.1128D+07
500.	0.0000D+00	0.7551D-11	0.1128D+07
510.	0.0000D+00	0.2175D-10	0.1128D+07
520.	0.0000D+00	0.5999D-10	0.1128D+07
530.	0.0000D+00	0.1588D-09	0.1128D+07
540.	0.0000D+00	0.4043D-09	0.1128D+07
550.	0.0000D+00	0.9922D-09	0.1128D+07
560.	0.0000D+00	0.2352D-08	0.1128D+07
570.	0.0000D+00	0.5395D-08	0.1128D+07
580.	0.0000D+00	0.1200D-07	0.1128D+07
590.	0.0000D+00	0.2589D-07	0.1128D+07
600.	0.0000D+00	0.5435D-07	0.1128D+07
610.	0.0000D+00	0.1111D-06	0.1128D+07
620.	0.0000D+00	0.2214D-06	0.1128D+07
630.	0.0000D+00	0.4307D-06	0.1128D+07
640.	0.0000D+00	0.8190D-06	0.1128D+07
650.	0.0000D+00	0.1524D-05	0.1128D+07
660.	0.0000D+00	0.2778D-05	0.1128D+07
670.	0.0000D+00	0.4964D-05	0.1128D+07
680.	0.0000D+00	0.8701D-05	0.1128D+07
690.	0.0000D+00	0.1498D-04	0.1128D+07
700.	0.0000D+00	0.2534D-04	0.1128D+07
710.	0.0000D+00	0.4216D-04	0.1128D+07
720.	0.0000D+00	0.6906D-04	0.1128D+07
730.	0.0000D+00	0.1114D-03	0.1128D+07
740.	0.0000D+00	0.1772D-03	0.1128D+07
750.	0.0000D+00	0.2778D-03	0.1128D+07
760.	0.0000D+00	0.4299D-03	0.1128D+07
770.	0.0000D+00	0.6567D-03	0.1128D+07
780.	0.0000D+00	0.9910D-03	0.1128D+07
790.	0.0000D+00	0.1478D-02	0.1128D+07
800.	0.0000D+00	0.2179D-02	0.1128D+07
810.	0.0000D+00	0.3179D-02	0.1128D+07
820.	0.0000D+00	0.4589D-02	0.1128D+07
830.	0.0000D+00	0.6558D-02	0.1128D+07
840.	0.0000D+00	0.9282D-02	0.1128D+07
850.	0.0000D+00	0.1301D-01	0.1128D+07
860.	0.0000D+00	0.1808D-01	0.1128D+07
870.	0.0000D+00	0.2491D-01	0.1128D+07
880.	0.0000D+00	0.3404D-01	0.1128D+07
890.	0.0000D+00	0.4613D-01	0.1128D+07
900.	0.0000D+00	0.6203D-01	0.1128D+07
910.	0.0000D+00	0.8280D-01	0.1128D+07
920.	0.0000D+00	0.1097D+00	0.1128D+07
930.	0.0000D+00	0.1444D+00	0.1128D+07

940.	0.0000D+00	0.1887D+00	0.1128D+07
950.	0.0000D+00	0.2451D+00	0.1128D+07
960.	0.0000D+00	0.3162D+00	0.1128D+07
970.	0.0000D+00	0.4056D+00	0.1128D+07
980.	0.0000D+00	0.5171D+00	0.1128D+07
990.	0.0000D+00	0.6555D+00	0.1128D+07
1000.	0.0000D+00	0.8268D+00	0.1128D+07

OTHER PERCHED WATER

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.4810D+07	0.1024D-45	0.8017D+06
20.	0.4009D+07	0.2354D-13	0.1603D+07
30.	0.3207D+07	0.8525D-04	0.2405D+07
40.	0.2405D+07	-0.4033D+00	0.3207D+07
50.	0.1603D+07	0.4498D+02	0.4009D+07
60.	0.8017D+06	0.4734D+03	0.4810D+07
70.	0.0000D+00	0.2023D+04	0.5610D+07
80.	0.0000D+00	0.5347D+04	0.5607D+07
90.	0.0000D+00	0.1035D+05	0.5602D+07
100.	0.0000D+00	0.1652D+05	0.5595D+07
110.	0.0000D+00	0.2351D+05	0.5588D+07
120.	0.0000D+00	0.3110D+05	0.5581D+07
130.	0.0000D+00	0.3885D+05	0.5573D+07
140.	0.0000D+00	0.4592D+05	0.5566D+07
150.	0.0000D+00	0.5164D+05	0.5560D+07
160.	0.0000D+00	0.5604D+05	0.5556D+07
170.	0.0000D+00	0.5961D+05	0.5552D+07
180.	0.0000D+00	0.6263D+05	0.5549D+07
190.	0.0000D+00	0.6527D+05	0.5547D+07
200.	0.0000D+00	0.6759D+05	0.5544D+07
210.	0.0000D+00	0.6967D+05	0.5542D+07
220.	0.0000D+00	0.7154D+05	0.5540D+07
230.	0.0000D+00	0.7324D+05	0.5539D+07
240.	0.0000D+00	0.7479D+05	0.5537D+07
250.	0.0000D+00	0.7622D+05	0.5536D+07
260.	0.0000D+00	0.7753D+05	0.5534D+07
270.	0.0000D+00	0.7874D+05	0.5533D+07
280.	0.0000D+00	0.7988D+05	0.5532D+07
290.	0.0000D+00	0.8093D+05	0.5531D+07
300.	0.0000D+00	0.8192D+05	0.5530D+07
310.	0.0000D+00	0.8285D+05	0.5529D+07
320.	0.0000D+00	0.8373D+05	0.5528D+07
330.	0.0000D+00	0.8457D+05	0.5527D+07
340.	0.0000D+00	0.8536D+05	0.5527D+07
350.	0.0000D+00	0.8611D+05	0.5526D+07
360.	0.0000D+00	0.8683D+05	0.5525D+07
370.	0.0000D+00	0.8752D+05	0.5524D+07
380.	0.0000D+00	0.8818D+05	0.5524D+07
390.	0.0000D+00	0.8881D+05	0.5523D+07
400.	0.0000D+00	0.8942D+05	0.5523D+07
410.	0.0000D+00	0.9001D+05	0.5522D+07
420.	0.0000D+00	0.9058D+05	0.5521D+07
430.	0.0000D+00	0.9114D+05	0.5521D+07
440.	0.0000D+00	0.9168D+05	0.5520D+07
450.	0.0000D+00	0.9220D+05	0.5520D+07
460.	0.0000D+00	0.9271D+05	0.5519D+07
470.	0.0000D+00	0.9321D+05	0.5519D+07
480.	0.0000D+00	0.9369D+05	0.5518D+07
490.	0.0000D+00	0.9417D+05	0.5518D+07

500.	0.0000D+00	0.9464D+05	0.5517D+07
510.	0.0000D+00	0.9510D+05	0.5517D+07
520.	0.0000D+00	0.9555D+05	0.5516D+07
530.	0.0000D+00	0.9600D+05	0.5516D+07
540.	0.0000D+00	0.9644D+05	0.5516D+07
550.	0.0000D+00	0.9688D+05	0.5515D+07
560.	0.0000D+00	0.9732D+05	0.5515D+07
570.	0.0000D+00	0.9776D+05	0.5514D+07
580.	0.0000D+00	0.9820D+05	0.5514D+07
590.	0.0000D+00	0.9864D+05	0.5513D+07
600.	0.0000D+00	0.9909D+05	0.5513D+07
610.	0.0000D+00	0.9954D+05	0.5512D+07
620.	0.0000D+00	0.1000D+06	0.5512D+07
630.	0.0000D+00	0.1005D+06	0.5512D+07
640.	0.0000D+00	0.1009D+06	0.5511D+07
650.	0.0000D+00	0.1014D+06	0.5511D+07
660.	0.0000D+00	0.1019D+06	0.5510D+07
670.	0.0000D+00	0.1025D+06	0.5510D+07
680.	0.0000D+00	0.1030D+06	0.5509D+07
690.	0.0000D+00	0.1035D+06	0.5508D+07
700.	0.0000D+00	0.1041D+06	0.5508D+07
710.	0.0000D+00	0.1047D+06	0.5507D+07
720.	0.0000D+00	0.1053D+06	0.5507D+07
730.	0.0000D+00	0.1060D+06	0.5506D+07
740.	0.0000D+00	0.1067D+06	0.5505D+07
750.	0.0000D+00	0.1074D+06	0.5505D+07
760.	0.0000D+00	0.1081D+06	0.5504D+07
770.	0.0000D+00	0.1089D+06	0.5503D+07
780.	0.0000D+00	0.1097D+06	0.5502D+07
790.	0.0000D+00	0.1105D+06	0.5501D+07
800.	0.0000D+00	0.1114D+06	0.5501D+07
810.	0.0000D+00	0.1123D+06	0.5500D+07
820.	0.0000D+00	0.1133D+06	0.5499D+07
830.	0.0000D+00	0.1142D+06	0.5498D+07
840.	0.0000D+00	0.1153D+06	0.5497D+07
850.	0.0000D+00	0.1164D+06	0.5496D+07
860.	0.0000D+00	0.1175D+06	0.5494D+07
870.	0.0000D+00	0.1187D+06	0.5493D+07
880.	0.0000D+00	0.1199D+06	0.5492D+07
890.	0.0000D+00	0.1212D+06	0.5491D+07
900.	0.0000D+00	0.1225D+06	0.5489D+07
910.	0.0000D+00	0.1239D+06	0.5488D+07
920.	0.0000D+00	0.1253D+06	0.5487D+07
930.	0.0000D+00	0.1268D+06	0.5485D+07
940.	0.0000D+00	0.1283D+06	0.5484D+07
950.	0.0000D+00	0.1299D+06	0.5482D+07
960.	0.0000D+00	0.1315D+06	0.5481D+07
970.	0.0000D+00	0.1332D+06	0.5479D+07
980.	0.0000D+00	0.1349D+06	0.5477D+07
990.	0.0000D+00	0.1367D+06	0.5475D+07
1000.	0.0000D+00	0.1385D+06	0.5473D+07

SURFACE SOIL CELLS WITHOUT CAP

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.2249D+11	0.0000D+00	0.8216D+08
20.	0.2241D+11	0.0000D+00	0.1640D+09
30.	0.2232D+11	0.0000D+00	0.2456D+09
40.	0.2224D+11	0.0000D+00	0.3268D+09
50.	0.2216D+11	0.0000D+00	0.4078D+09

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60.	0.2208D+11	0.0000D+00	0.4885D+09
70.	0.2200D+11	0.0000D+00	0.5689D+09
80.	0.2192D+11	0.0000D+00	0.6490D+09
90.	0.2184D+11	0.0000D+00	0.7288D+09
100.	0.2176D+11	0.0000D+00	0.8083D+09
110.	0.2168D+11	0.0000D+00	0.8875D+09
120.	0.2160D+11	0.0000D+00	0.9664D+09
130.	0.2152D+11	0.0000D+00	0.1045D+10
140.	0.2145D+11	0.0000D+00	0.1123D+10
150.	0.2137D+11	0.0000D+00	0.1201D+10
160.	0.2129D+11	0.0000D+00	0.1279D+10
170.	0.2121D+11	0.0000D+00	0.1357D+10
180.	0.2114D+11	0.0000D+00	0.1434D+10
190.	0.2106D+11	0.0000D+00	0.1511D+10
200.	0.2098D+11	0.0000D+00	0.1588D+10
210.	0.2091D+11	0.0000D+00	0.1664D+10
220.	0.2083D+11	0.0000D+00	0.1740D+10
230.	0.2075D+11	0.0000D+00	0.1816D+10
240.	0.2068D+11	0.0000D+00	0.1891D+10
250.	0.2060D+11	0.0000D+00	0.1967D+10
260.	0.2053D+11	0.0000D+00	0.2042D+10
270.	0.2045D+11	0.0000D+00	0.2116D+10
280.	0.2038D+11	0.0000D+00	0.2191D+10
290.	0.2030D+11	0.0000D+00	0.2265D+10
300.	0.2023D+11	0.0000D+00	0.2339D+10
310.	0.2016D+11	0.0000D+00	0.2413D+10
320.	0.2008D+11	0.0000D+00	0.2486D+10
330.	0.2001D+11	0.0000D+00	0.2559D+10
340.	0.1994D+11	0.0000D+00	0.2632D+10
350.	0.1987D+11	0.0000D+00	0.2705D+10
360.	0.1979D+11	0.0000D+00	0.2777D+10
370.	0.1972D+11	0.0000D+00	0.2849D+10
380.	0.1965D+11	0.0000D+00	0.2921D+10
390.	0.1958D+11	0.0000D+00	0.2992D+10
400.	0.1951D+11	0.0000D+00	0.3064D+10
410.	0.1944D+11	0.0000D+00	0.3135D+10
420.	0.1936D+11	0.0000D+00	0.3205D+10
430.	0.1929D+11	0.0000D+00	0.3276D+10
440.	0.1922D+11	0.0000D+00	0.3346D+10
450.	0.1915D+11	0.0000D+00	0.3416D+10
460.	0.1908D+11	0.0000D+00	0.3486D+10
470.	0.1901D+11	0.0000D+00	0.3555D+10
480.	0.1895D+11	0.0000D+00	0.3624D+10
490.	0.1888D+11	0.0000D+00	0.3693D+10
500.	0.1881D+11	0.0000D+00	0.3762D+10
510.	0.1874D+11	0.0000D+00	0.3831D+10
520.	0.1867D+11	0.0000D+00	0.3899D+10
530.	0.1860D+11	0.0000D+00	0.3967D+10
540.	0.1854D+11	0.0000D+00	0.4034D+10
550.	0.1847D+11	0.0000D+00	0.4102D+10
560.	0.1840D+11	0.0000D+00	0.4169D+10
570.	0.1833D+11	0.0000D+00	0.4236D+10
580.	0.1827D+11	0.0000D+00	0.4303D+10
590.	0.1820D+11	0.0000D+00	0.4369D+10
600.	0.1813D+11	0.0000D+00	0.4436D+10
610.	0.1807D+11	0.0000D+00	0.4502D+10
620.	0.1800D+11	0.0000D+00	0.4567D+10
630.	0.1794D+11	0.0000D+00	0.4633D+10
640.	0.1787D+11	0.0000D+00	0.4698D+10
650.	0.1781D+11	0.0000D+00	0.4763D+10
660.	0.1774D+11	0.0000D+00	0.4828D+10
670.	0.1768D+11	0.0000D+00	0.4893D+10
680.	0.1761D+11	0.0000D+00	0.4957D+10
690.	0.1755D+11	0.0000D+00	0.5021D+10
700.	0.1748D+11	0.0000D+00	0.5085D+10

710.	0.1742D+11	0.0000D+00	0.5149D+10
720.	0.1736D+11	0.0000D+00	0.5212D+10
730.	0.1729D+11	0.0000D+00	0.5275D+10
740.	0.1723D+11	0.0000D+00	0.5338D+10
750.	0.1717D+11	0.0000D+00	0.5401D+10
760.	0.1711D+11	0.0000D+00	0.5463D+10
770.	0.1704D+11	0.0000D+00	0.5526D+10
780.	0.1698D+11	0.0000D+00	0.5588D+10
790.	0.1692D+11	0.0000D+00	0.5650D+10
800.	0.1686D+11	0.0000D+00	0.5711D+10
810.	0.1680D+11	0.0000D+00	0.5773D+10
820.	0.1674D+11	0.0000D+00	0.5834D+10
830.	0.1668D+11	0.0000D+00	0.5895D+10
840.	0.1661D+11	0.0000D+00	0.5955D+10
850.	0.1655D+11	0.0000D+00	0.6016D+10
860.	0.1649D+11	0.0000D+00	0.6076D+10
870.	0.1643D+11	0.0000D+00	0.6136D+10
880.	0.1637D+11	0.0000D+00	0.6196D+10
890.	0.1631D+11	0.0000D+00	0.6256D+10
900.	0.1626D+11	0.0000D+00	0.6315D+10
910.	0.1620D+11	0.0000D+00	0.6374D+10
920.	0.1614D+11	0.0000D+00	0.6433D+10
930.	0.1608D+11	0.0000D+00	0.6492D+10
940.	0.1602D+11	0.0000D+00	0.6550D+10
950.	0.1596D+11	0.0000D+00	0.6609D+10
960.	0.1590D+11	0.0000D+00	0.6667D+10
970.	0.1585D+11	0.0000D+00	0.6725D+10
980.	0.1579D+11	0.0000D+00	0.6782D+10
990.	0.1573D+11	0.0000D+00	0.6840D+10
1000.	0.1567D+11	0.0000D+00	0.6897D+10

SURFACE SOIL CELLS WITH CAP

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.6185D+10	0.0000D+00	0.2746D+07
20.	0.6183D+10	0.0000D+00	0.5490D+07
30.	0.6180D+10	0.0000D+00	0.8234D+07
40.	0.6177D+10	0.0000D+00	0.1098D+08
50.	0.6174D+10	0.0000D+00	0.1372D+08
60.	0.6172D+10	0.0000D+00	0.1646D+08
70.	0.6169D+10	0.0000D+00	0.1919D+08
80.	0.6166D+10	0.0000D+00	0.2193D+08
90.	0.6163D+10	0.0000D+00	0.2467D+08
100.	0.6161D+10	0.0000D+00	0.2740D+08
110.	0.6158D+10	0.0000D+00	0.3014D+08
120.	0.6155D+10	0.0000D+00	0.3287D+08
130.	0.6152D+10	0.0000D+00	0.3560D+08
140.	0.6150D+10	0.0000D+00	0.3833D+08
150.	0.6147D+10	0.0000D+00	0.4106D+08
160.	0.6144D+10	0.0000D+00	0.4379D+08
170.	0.6141D+10	0.0000D+00	0.4651D+08
180.	0.6139D+10	0.0000D+00	0.4924D+08
190.	0.6136D+10	0.0000D+00	0.5196D+08
200.	0.6133D+10	0.0000D+00	0.5468D+08
210.	0.6131D+10	0.0000D+00	0.5741D+08
220.	0.6128D+10	0.0000D+00	0.6013D+08
230.	0.6125D+10	0.0000D+00	0.6285D+08
240.	0.6122D+10	0.0000D+00	0.6556D+08
250.	0.6120D+10	0.0000D+00	0.6828D+08
260.	0.6117D+10	0.0000D+00	0.7100D+08

270.	0.6114D+10	0.0000D+00	0.7371D+08
280.	0.6112D+10	0.0000D+00	0.7642D+08
290.	0.6109D+10	0.0000D+00	0.7913D+08
300.	0.6106D+10	0.0000D+00	0.8185D+08
310.	0.6103D+10	0.0000D+00	0.8456D+08
320.	0.6101D+10	0.0000D+00	0.8726D+08
330.	0.6098D+10	0.0000D+00	0.8997D+08
340.	0.6095D+10	0.0000D+00	0.9268D+08
350.	0.6093D+10	0.0000D+00	0.9538D+08
360.	0.6090D+10	0.0000D+00	0.9808D+08
370.	0.6087D+10	0.0000D+00	0.1008D+09
380.	0.6085D+10	0.0000D+00	0.1035D+09
390.	0.6082D+10	0.0000D+00	0.1062D+09
400.	0.6079D+10	0.0000D+00	0.1089D+09
410.	0.6076D+10	0.0000D+00	0.1116D+09
420.	0.6074D+10	0.0000D+00	0.1143D+09
430.	0.6071D+10	0.0000D+00	0.1170D+09
440.	0.6068D+10	0.0000D+00	0.1197D+09
450.	0.6066D+10	0.0000D+00	0.1224D+09
460.	0.6063D+10	0.0000D+00	0.1251D+09
470.	0.6060D+10	0.0000D+00	0.1277D+09
480.	0.6058D+10	0.0000D+00	0.1304D+09
490.	0.6055D+10	0.0000D+00	0.1331D+09
500.	0.6052D+10	0.0000D+00	0.1358D+09
510.	0.6050D+10	0.0000D+00	0.1385D+09
520.	0.6047D+10	0.0000D+00	0.1412D+09
530.	0.6044D+10	0.0000D+00	0.1439D+09
540.	0.6041D+10	0.0000D+00	0.1465D+09
550.	0.6039D+10	0.0000D+00	0.1492D+09
560.	0.6036D+10	0.0000D+00	0.1519D+09
570.	0.6033D+10	0.0000D+00	0.1546D+09
580.	0.6031D+10	0.0000D+00	0.1573D+09
590.	0.6028D+10	0.0000D+00	0.1599D+09
600.	0.6025D+10	0.0000D+00	0.1626D+09
610.	0.6023D+10	0.0000D+00	0.1653D+09
620.	0.6020D+10	0.0000D+00	0.1680D+09
630.	0.6017D+10	0.0000D+00	0.1706D+09
640.	0.6015D+10	0.0000D+00	0.1733D+09
650.	0.6012D+10	0.0000D+00	0.1760D+09
660.	0.6009D+10	0.0000D+00	0.1786D+09
670.	0.6007D+10	0.0000D+00	0.1813D+09
680.	0.6004D+10	0.0000D+00	0.1840D+09
690.	0.6001D+10	0.0000D+00	0.1866D+09
700.	0.5999D+10	0.0000D+00	0.1893D+09
710.	0.5996D+10	0.0000D+00	0.1920D+09
720.	0.5993D+10	0.0000D+00	0.1946D+09
730.	0.5991D+10	0.0000D+00	0.1973D+09
740.	0.5988D+10	0.0000D+00	0.1999D+09
750.	0.5985D+10	0.0000D+00	0.2026D+09
760.	0.5983D+10	0.0000D+00	0.2052D+09
770.	0.5980D+10	0.0000D+00	0.2079D+09
780.	0.5977D+10	0.0000D+00	0.2106D+09
790.	0.5975D+10	0.0000D+00	0.2132D+09
800.	0.5972D+10	0.0000D+00	0.2159D+09
810.	0.5969D+10	0.0000D+00	0.2185D+09
820.	0.5967D+10	0.0000D+00	0.2212D+09
830.	0.5964D+10	0.0000D+00	0.2238D+09
840.	0.5962D+10	0.0000D+00	0.2264D+09
850.	0.5959D+10	0.0000D+00	0.2291D+09
860.	0.5956D+10	0.0000D+00	0.2317D+09
870.	0.5954D+10	0.0000D+00	0.2344D+09
880.	0.5951D+10	0.0000D+00	0.2370D+09
890.	0.5948D+10	0.0000D+00	0.2397D+09
900.	0.5946D+10	0.0000D+00	0.2423D+09
910.	0.5943D+10	0.0000D+00	0.2449D+09

920.	0.5940D+10	0.0000D+00	0.2476D+09
930.	0.5938D+10	0.0000D+00	0.2502D+09
940.	0.5935D+10	0.0000D+00	0.2528D+09
950.	0.5933D+10	0.0000D+00	0.2555D+09
960.	0.5930D+10	0.0000D+00	0.2581D+09
970.	0.5927D+10	0.0000D+00	0.2607D+09
980.	0.5925D+10	0.0000D+00	0.2634D+09
990.	0.5922D+10	0.0000D+00	0.2660D+09
1000.	0.5919D+10	0.0000D+00	0.2686D+09

SUM OF OU-2 WASTE AREAS

TIME (YR)	REMAINING SOURCE MASS (MG)	MASS EXITING BOTTOM	DECAYED + SORBED + DISSOLVED
10.	0.1259D+11	0.0000D+00	0.6621D+08
20.	0.1253D+11	0.0000D+00	0.1324D+09
30.	0.1246D+11	0.2064D-35	0.1986D+09
40.	0.1240D+11	0.1376D-21	0.2648D+09
50.	0.1233D+11	0.8770D-13	0.3310D+09
60.	0.1226D+11	0.3336D-07	0.3972D+09
70.	0.1220D+11	0.1986D-03	0.4633D+09
80.	0.1216D+11	0.9217D-01	0.4980D+09
90.	0.1213D+11	0.7951D+01	0.5328D+09
100.	0.1209D+11	0.2239D+03	0.5675D+09
110.	0.1206D+11	0.2601D+04	0.6022D+09
120.	0.1202D+11	0.1634D+05	0.6369D+09
130.	0.1199D+11	0.6531D+05	0.6713D+09
140.	0.1195D+11	0.1884D+06	0.7059D+09
150.	0.1192D+11	0.4296D+06	0.7403D+09
160.	0.1188D+11	0.8245D+06	0.7746D+09
170.	0.1185D+11	0.1393D+07	0.8082D+09
180.	0.1182D+11	0.2140D+07	0.8375D+09
190.	0.1179D+11	0.3052D+07	0.8633D+09
200.	0.1177D+11	0.4112D+07	0.8890D+09
210.	0.1174D+11	0.5294D+07	0.9142D+09
220.	0.1171D+11	0.6578D+07	0.9396D+09
230.	0.1169D+11	0.7943D+07	0.9650D+09
240.	0.1166D+11	0.9375D+07	0.9899D+09
250.	0.1163D+11	0.1086D+08	0.1015D+10
260.	0.1161D+11	0.1240D+08	0.1034D+10
270.	0.1159D+11	0.1399D+08	0.1051D+10
280.	0.1158D+11	0.1560D+08	0.1068D+10
290.	0.1156D+11	0.1725D+08	0.1085D+10
300.	0.1154D+11	0.1893D+08	0.1102D+10
310.	0.1152D+11	0.2062D+08	0.1118D+10
320.	0.1150D+11	0.2233D+08	0.1135D+10
330.	0.1148D+11	0.2405D+08	0.1152D+10
340.	0.1147D+11	0.2578D+08	0.1168D+10
350.	0.1145D+11	0.2752D+08	0.1185D+10
360.	0.1143D+11	0.2927D+08	0.1202D+10
370.	0.1141D+11	0.3102D+08	0.1218D+10
380.	0.1139D+11	0.3279D+08	0.1235D+10
390.	0.1137D+11	0.3456D+08	0.1251D+10
400.	0.1136D+11	0.3634D+08	0.1268D+10
410.	0.1134D+11	0.3813D+08	0.1284D+10
420.	0.1132D+11	0.3992D+08	0.1301D+10
430.	0.1130D+11	0.4172D+08	0.1317D+10
440.	0.1128D+11	0.4352D+08	0.1334D+10
450.	0.1126D+11	0.4532D+08	0.1350D+10
460.	0.1125D+11	0.4712D+08	0.1367D+10
470.	0.1123D+11	0.4890D+08	0.1383D+10
480.	0.1121D+11	0.5066D+08	0.1400D+10

490.	0.1119D+11	0.5240D+08	0.1416D+10
500.	0.1117D+11	0.5411D+08	0.1433D+10
510.	0.1115D+11	0.5581D+08	0.1449D+10
520.	0.1114D+11	0.5748D+08	0.1466D+10
530.	0.1112D+11	0.5914D+08	0.1483D+10
540.	0.1110D+11	0.6080D+08	0.1499D+10
550.	0.1108D+11	0.6244D+08	0.1516D+10
560.	0.1106D+11	0.6407D+08	0.1532D+10
570.	0.1104D+11	0.6570D+08	0.1549D+10
580.	0.1103D+11	0.6732D+08	0.1566D+10
590.	0.1101D+11	0.6893D+08	0.1582D+10
600.	0.1099D+11	0.7054D+08	0.1599D+10
610.	0.1097D+11	0.7213D+08	0.1615D+10
620.	0.1095D+11	0.7373D+08	0.1632D+10
630.	0.1094D+11	0.7532D+08	0.1648D+10
640.	0.1092D+11	0.7689D+08	0.1665D+10
650.	0.1090D+11	0.7849D+08	0.1682D+10
660.	0.1088D+11	0.8005D+08	0.1698D+10
670.	0.1086D+11	0.8162D+08	0.1715D+10
680.	0.1085D+11	0.8319D+08	0.1731D+10
690.	0.1083D+11	0.8474D+08	0.1748D+10
700.	0.1081D+11	0.8628D+08	0.1764D+10
710.	0.1079D+11	0.8784D+08	0.1781D+10
720.	0.1077D+11	0.8938D+08	0.1798D+10
730.	0.1075D+11	0.9093D+08	0.1814D+10
740.	0.1074D+11	0.9245D+08	0.1831D+10
750.	0.1072D+11	0.9398D+08	0.1847D+10
760.	0.1070D+11	0.9551D+08	0.1864D+10
770.	0.1068D+11	0.9703D+08	0.1880D+10
780.	0.1066D+11	0.9853D+08	0.1897D+10
790.	0.1065D+11	0.1000D+09	0.1914D+10
800.	0.1063D+11	0.1015D+09	0.1930D+10
810.	0.1061D+11	0.1030D+09	0.1947D+10
820.	0.1059D+11	0.1045D+09	0.1963D+10
830.	0.1057D+11	0.1060D+09	0.1980D+10
840.	0.1056D+11	0.1075D+09	0.1996D+10
850.	0.1054D+11	0.1090D+09	0.2013D+10
860.	0.1052D+11	0.1105D+09	0.2030D+10
870.	0.1050D+11	0.1119D+09	0.2046D+10
880.	0.1048D+11	0.1134D+09	0.2063D+10
890.	0.1047D+11	0.1149D+09	0.2079D+10
900.	0.1045D+11	0.1163D+09	0.2096D+10
910.	0.1043D+11	0.1178D+09	0.2112D+10
920.	0.1041D+11	0.1192D+09	0.2129D+10
930.	0.1039D+11	0.1207D+09	0.2145D+10
940.	0.1038D+11	0.1221D+09	0.2162D+10
950.	0.1036D+11	0.1235D+09	0.2178D+10
960.	0.1034D+11	0.1249D+09	0.2195D+10
970.	0.1032D+11	0.1264D+09	0.2212D+10
980.	0.1030D+11	0.1278D+09	0.2228D+10
990.	0.1029D+11	0.1292D+09	0.2245D+10
1000.	0.1027D+11	0.1306D+09	0.2261D+10

ATTACHMENT I.III

AIR FATE AND TRANSPORT MODELING INPUT AND OUTPUT

000497

ATTACHMENT I.III-1
RAECOM MODEL OUTPUT

OU2 RESIDUAL EMISSIONS: AFP, EXPOSED GMA

********** 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:	.2624	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.3682E-01	.6750	.3000E-06	22.40

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

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.2624E+00	.0000E+00	.7845

OU2 RESIDUAL EMISSIONS: AFP, EXPOSED TILL

********** 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:	.4977	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.2180E-01	.6140	.8000E-06	26.00

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

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.4977E+00	.0000E+00	.6734

OU2 RESIDUAL EMISSIONS: IFP, EXPOSED GMA

********** 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: .5047 pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.2276E-01	.5420	.9000E-06	16.90

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

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.5047E+00	.0000E+00	.7147

OU2 RESIDUAL EMISSIONS: IFP, EXPOSED TILL

********** 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:	.4339	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.3350E-01	.6990	.5000E-06	30.10

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

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.4339E+00	.0000E+00	.7410

OU2 RESIDUAL EMISSIONS: SF, EXPOSED GMA

********** 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: .1030 pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.6550E-03	.3240	.1800E-05	14.90

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

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.1030E+00	.0000E+00	.3789

OU2 RESIDUAL EMISSIONS: SF, EXPOSED TILL

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

NUMBER OF LAYERS: 1
RADON FLUX INTO LAYER 1: .000 pCi/m2/sec
SURFACE RADON CONCENTRATION: .000 pCi/LITER

LAYER 1 EXCEEDS SATURATION. MOISTURE CHANGED FROM .216 TO .186

BARE SOURCE FLUX (Jo) FROM LAYER 1: .4269E-01pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.4650E-04	.3360	.2700E-05	18.55

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

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.4269E-01	.0000E+00	.2674

ATTACHMENT I.III-2
METEOROLOGICAL DATA -
FEMP STANDARD JOINT FREQUENCY DISTRIBUTION:
1987 - 1992 COMPOSITE

COMPOSITE JOINT FREQUENCY DISTRIBUTION OF THE
1987–1992 ON–PROPERTY WIND DATA (FEMP STANDARD)

Wind Direction	Wind Speed, mph 1 – 3	4 – 7	8 – 12	13 – 18	19 – 24	> 24
Stability 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
Stability 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

COMPOSITE JOINT FREQUENCY DISTRIBUTION OF THE
1987–1992 ON–PROPERTY WIND DATA (FEMP STANDARD)
(Continued)

Wind Direction	Wind Speed, mph 1 – 3	4 – 7	8 – 12	13 – 18	19 – 24	> 24
Stability 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
Stability 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

COMPOSITE JOINT FREQUENCY DISTRIBUTION OF THE
1987–1992 ON–PROPERTY WIND DATA (FEMP STANDARD)
(Continued)

Wind Direction	Wind Speed, mph 1 – 3	4 – 7	8 – 12	13 – 18	19 – 24	> 24
Stability 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
Stability 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

ATTACHMENT I.III-3
ISCLT2 MODEL OUTPUT

The ISCLT2 output files represent several hundred pages of codified information. This information is summarized in Tables I.6-14 and I.6-15. Printouts of the output files are available upon request.

ATTACHMENT I.IV
EXPOSURE CALCULATIONS

ATTACHMENT I.IV-1
INTAKE AND RISK CALCULATIONS

FEMP-OU1&2CRARE-3-DRAFT
April 29, 1994

INTAKE AND RISK CALCULATIONS:
CURRENT LAND USE SCENARIO

Table I.IV-1
Summary of Intake Quantitation (chemicals)
Trespassing Child Current Land Use Scenario (age7-18)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	0.83 m^3\hour
ET	Exposure time	4 hours\day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non-carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3
4,4-DDE	1.0E-09	mg/m^3
Antimony	5.5E-07	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3
Arsenic	5.3E-07	mg/m^3
Barium	8.7E-06	mg/m^3
Beryllium	6.0E-08	mg/m^3
Boron	1.1E-05	mg/m^3
Cadmium	3.7E-07	mg/m^3
Carbazole	7.3E-09	mg/m^3
Chromium	1.2E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3
Copper	2.0E-06	mg/m^3

Compound	Concentration	Units
Cyanide	2.3E-08	mg/m^3
Endrin	1.5E-10	mg/m^3
Lead	2.1E-06	mg/m^3
Manganese	7.7E-05	mg/m^3
Mercury	2.8E-08	mg/m^3
Molybdenum	5.4E-07	mg/m^3
Nickel	1.8E-06	mg/m^3
Selenium	6.5E-08	mg/m^3
Silver	6.5E-07	mg/m^3
Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Thallium	4.4E-08	mg/m^3
Thorium	2.3E-06	mg/m^3
Uranium	5.8E-05	mg/m^3
Vanadium	2.1E-06	mg/m^3
Zinc	6.3E-06	mg/m^3

References

Table I.IV-1 (continued)
Summary of Risk Characterization (chemicals)
Trespassing Child Current Land Use Scenario (age7-18)
Via Inhalation of Particulates

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	4.3E-11	NA	NA
4,4-DDE	1.1E-11	NA	NA
Antimony	6.0E-09	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	3.8E-10	NA	NA
Aroclor-1260	2.1E-10	NA	NA
Arsenic	5.9E-09	NA	NA
Barium	9.6E-08	1.0E-04	9.6E-04
Beryllium	6.6E-10	NA	NA
Boron	1.2E-07	5.7E-03	2.1E-05
Cadmium	4.1E-09	NA	NA
Carbazole	8.1E-11	NA	NA
Chromium	1.3E-08	NA	NA
Cobalt	1.0E-08	3.0E-07	3.4E-02
Copper	2.2E-08	NA	NA
Cyanide	2.5E-10	NA	NA
Endrin	1.6E-12	NA	NA
Lead	2.3E-08	NA	NA
Manganese	8.4E-07	1.1E-04	7.7E-03
Mercury	3.0E-10	8.6E-05	3.5E-06
Molybdenum	5.9E-09	NA	NA
Nickel	2.0E-08	NA	NA
Selenium	7.2E-10	NA	NA
Silver	7.1E-09	NA	NA
Tetrachlordibenzo-p-dioxin	2.3E-16	NA	NA
Thallium	4.8E-10	NA	NA
Thorium	2.5E-08	NA	NA
Uranium	6.4E-07	NA	NA
Vanadium	2.3E-08	NA	NA
Zinc	6.9E-08	NA	NA
	HQ Summation =		4.3E-02

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	7.4E-12	NA	NA
4,4-DDE	1.9E-12	NA	NA
Antimony	1.0E-09	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	6.4E-11	NA	NA
Aroclor-1260	3.6E-11	NA	NA
Arsenic	1.0E-09	1.5E+01	1.5E-08
Barium	1.6E-08	NA	NA
Beryllium	1.1E-10	8.4E+00	9.4E-10
Boron	2.1E-08	NA	NA
Cadmium	7.1E-10	6.1E+00	4.3E-09
Carbazole	1.4E-11	NA	NA
Chromium	2.3E-09	4.1E+01	9.4E-08
Cobalt	1.8E-09	NA	NA
Copper	3.8E-09	NA	NA
Cyanide	4.3E-11	NA	NA
Endrin	2.8E-13	NA	NA
Lead	4.0E-09	NA	NA
Manganese	1.4E-07	NA	NA
Mercury	5.2E-11	NA	NA
Molybdenum	1.0E-09	NA	NA
Nickel	3.4E-09	8.4E-01	2.8E-09
Selenium	1.2E-10	NA	NA
Silver	1.2E-09	NA	NA
Tetrachlordibenzo-p-dioxin	3.9E-17	1.5E+05	5.8E-12
Thallium	8.3E-11	NA	NA
Thorium	4.3E-09	NA	NA
Uranium	1.1E-07	NA	NA
Vanadium	4.0E-09	NA	NA
Zinc	1.2E-08	NA	NA
	ILCR Summation =		1.2E-07

Table I.IV–2
Summary of Intake and Risk Quantitation (Radionuclides)
Trespassing Child Current Land Use Scenario (age7–18)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X ET X IR

IR	Inhalation rate of gases (RAGS, 1989)	0.83 m^3\hour
EF	Exposure frequency	52 days/year
EDn	Exposure duration	12 Year
ET	Exposure time	4 hours\day
Ca	Concentration of radionuclides in air	

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	9.9E-02	1.9E-11	1.9E-12
Np-237	4.0E-02	2.9E-08	1.2E-09
Pa-231	4.1E-02	3.6E-08	1.5E-09
Pb-210	1.7E-01	4.0E-09	6.9E-10
Pu-238	6.3E-02	3.9E-08	2.4E-09
Pu-239	1.6E-02	3.8E-08	6.0E-10
Pu-240	5.7E-02	3.8E-08	2.2E-09
Ra-226	6.5E-02	3.0E-09	2.0E-10
Ra-228	1.1E-01	6.9E-10	7.8E-11
Rn-222	5.5E+03	7.7E-12	4.2E-08
Ru-106	1.7E-02	4.4E-10	7.6E-12
Sr-90	1.7E-01	6.2E-11	1.0E-11
Tc-99	8.0E-01	8.3E-12	6.7E-12
Th-228	7.4E-02	7.8E-08	5.8E-09
Th-230	5.3E-01	2.9E-08	1.6E-08
Th-232	1.9E-01	2.8E-08	5.4E-09
U-234	5.0E+00	2.6E-08	1.3E-07
U-235	2.0E-01	2.5E-08	5.0E-09
U-236	1.2E+00	2.5E-08	3.0E-08
U-238	2.5E+00	5.2E-11	1.3E-10
		ILCR Summation =	2.4E-07

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Table I.IV-3
Summary of Intake Quantitation (chemicals)
Trespassing Child Current Land Use Scenario (age7-18)
Via Incidental Ingestion of Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	25 mg/day
CF	Conversion factor	1.00E-06 kg/mg
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non-carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/kg
4,4-DDE	NA	mg/kg
Antimony	5.4E+00	mg/kg
Aroclor-1221	NA	mg/kg
Aroclor-1248	NA	mg/kg
Aroclor-1254	NA	mg/kg
Aroclor-1260	NA	mg/kg
Arsenic	5.1E+00	mg/kg
Barium	9.7E+01	mg/kg
Beryllium	7.6E-01	mg/kg
Boron	1.1E+02	mg/kg
Cadmium	3.5E+00	mg/kg
Carbazole	NA	mg/kg
Chromium	1.6E+01	mg/kg
Cobalt	1.2E+01	mg/kg
Copper	2.0E+01	mg/kg

Compound	Concentration	Units
Cyanide	2.5E-01	mg/kg
Endrin	NA	mg/kg
Lead	2.4E+01	mg/kg
Manganese	9.8E+02	mg/kg
Mercury	2.1E-01	mg/kg
Molybdenum	6.5E+00	mg/kg
Nickel	2.3E+01	mg/kg
Selenium	6.3E-01	mg/kg
Silver	6.0E+00	mg/kg
Tetrachlordibenzo-p-dioxin	3.5E-08	mg/kg
Thallium	5.6E-01	mg/kg
Thorium	NA	mg/kg
Uranium	NA	mg/kg
Vanadium	2.6E+01	mg/kg
Zinc	6.4E+01	mg/kg

References

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Table I.IV-3 (continued)
Summary of Risk Characterization (chemicals)
Trespassing Child Current Land Use Scenario (age7-18)
Via Incidental Ingestion of Soil/Sediment

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	4.4E-07	4.0E-04	1.1E-03
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	4.2E-07	3.0E-04	1.4E-03
Barium	8.1E-06	7.0E-02	1.2E-04
Beryllium	6.3E-08	5.0E-03	1.3E-05
Boron	9.3E-06	9.0E-02	1.0E-04
Cadmium	2.9E-07	1.0E-03	2.9E-04
Carbazole	NA	NA	NA
Chromium	1.4E-06	5.0E-03	2.7E-04
Cobalt	1.0E-06	6.0E-02	1.7E-05
Copper	1.7E-06	NA	NA
Cyanide	2.1E-08	2.0E-02	1.0E-06
Endrin	NA	3.0E-04	NA
Lead	1.9E-06	NA	NA
Manganese	8.1E-05	1.4E-01	5.8E-04
Mercury	1.8E-08	3.0E-04	5.9E-05
Molybdenum	5.4E-07	5.0E-03	1.1E-04
Nickel	1.9E-06	2.0E-02	9.4E-05
Selenium	5.2E-08	5.0E-03	1.0E-05
Silver	5.0E-07	5.0E-03	1.0E-04
Tetrachlordibenzo-p-dioxin	2.9E-15	NA	NA
Thallium	4.6E-08	8.0E-05	5.8E-04
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	NA
Vanadium	2.2E-06	7.0E-03	3.1E-04
Zinc	5.3E-06	3.0E-01	1.8E-05
	HQ Summation =		5.2E-03

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	7.6E-08	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	7.2E-08	1.8E+00	1.3E-07
Barium	1.4E-06	NA	NA
Beryllium	1.1E-08	4.3E+00	4.6E-08
Boron	1.6E-06	NA	NA
Cadmium	4.9E-08	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	2.3E-07	NA	NA
Cobalt	1.7E-07	NA	NA
Copper	2.9E-07	NA	NA
Cyanide	3.5E-09	NA	NA
Endrin	NA	NA	NA
Lead	3.3E-07	NA	NA
Manganese	1.4E-05	NA	NA
Mercury	3.0E-09	NA	NA
Molybdenum	9.2E-08	NA	NA
Nickel	3.2E-07	NA	NA
Selenium	9.0E-09	NA	NA
Silver	8.6E-08	NA	NA
Tetrachlordibenzo-p-dioxin	4.9E-16	1.5E+05	7.4E-11
Thallium	7.9E-09	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	3.7E-07	NA	NA
Zinc	9.1E-07	NA	NA
	ILCR Summation =		1.8E-07

Table I.IV-4
Summary of Intake and Risk Quantitation (Radionuclides)
Trespassing Child Current Land Use Scenario (age7-18)
Via Incidental Ingestion of Soil/Sediment

Intake Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	25 mg/day
EF	Exposure frequency	52 days/year
EDn	Exposure Duration	12 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	(see table below)

Cs-137	5.8E-04	pCi/mg	Ru-106	1.3E-04	pCi/mg
Np-237	8.4E-05	pCi/mg	Sr-90	8.3E-04	pCi/mg
Pa-231	NA	pCi/mg	Tc-99	1.9E-03	pCi/mg
Pb-210	1.1E-03	pCi/mg	Th-228	4.0E-04	pCi/mg
Pu-238	9.1E-05	pCi/mg	Th-230	5.9E-05	pCi/mg
Pu-239	1.3E-05	pCi/mg	Th-232	6.0E-04	pCi/mg
Pu-240	4.6E-05	pCi/mg	U-234	2.1E-02	pCi/mg
Ra-226	4.0E-04	pCi/mg	U-235	9.3E-04	pCi/mg
Ra-228	7.0E-04	pCi/mg	U-236	6.9E-03	pCi/mg
Rn-222	NA	pCi/mg	U-238	1.4E-02	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	9.1E+00	2.8E-11	2.6E-10
Np-237	1.3E+00	2.2E-10	2.9E-10
Pa-231	NA	9.2E-11	NA
Pb-210	1.6E+01	6.6E-10	1.1E-08
Pu-238	1.4E+00	2.2E-10	3.1E-10
Pu-239	2.0E-01	2.3E-10	4.5E-11
Pu-240	7.1E-01	2.3E-10	1.6E-10
Ra-226	6.2E+00	1.2E-10	7.5E-10
Ra-228	1.1E+01	1.0E-10	1.1E-09
Rn-222	NA	1.7E-12	NA
Ru-106	2.1E+00	9.5E-12	2.0E-11
Sr-90	1.3E+01	3.6E-11	4.7E-10
Tc-99	2.9E+01	1.3E-12	3.8E-11
Th-228	6.2E+00	5.5E-11	3.4E-10
Th-230	9.2E-01	1.3E-11	1.2E-11
Th-232	9.3E+00	1.2E-11	1.1E-10
U-234	3.2E+02	1.6E-11	5.1E-09
U-235	1.5E+01	1.6E-11	2.3E-10
U-236	1.1E+02	1.5E-11	1.6E-09
U-238	2.2E+02	2.8E-11	6.0E-09
		ILCR Summation =	2.8E-08

Table I.IV-5
Summary of Intake and Risk Quantitation (Radionuclides)
Trespassing Child Current Land Use Scenario (age7-18)
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	12	Year
FI	Fractional intake for radionuclides	1	(Unitless)
Cs	Concentration of radionuclides in surface water		(see table below)

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	NA	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	3.3E+02	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	2.7E+00	pCi/l
Ra-226	NA	pCi/l	U-235	7.0E-02	pCi/l
Ra-228	NA	pCi/l	U-236	2.9E-02	pCi/l
Rn-222	NA	pCi/l	U-238	1.6E+00	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	NA	2.2E-10	NA
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	9.8E+02	1.3E-12	1.3E-09
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	7.8E+00	1.6E-11	1.2E-10
U-235	2.1E-01	1.6E-11	3.3E-12
U-236	8.5E-02	1.5E-11	1.3E-12
U-238	4.7E+00	2.8E-11	1.3E-10
		ILCR Summation =	1.5E-09

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Table I.IV-6
Summary of Intake Quantitation (chemicals)
Trespassing Child Current Land Use Scenario (age7-18)
Via Dermal Contact with Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	4200 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	52 days/year
EDn	Exposure duration for non-carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	ABS	Concentrati	Units
2-Methylnaphthalene	3.0E-01	NA	mg/kg
4,4-DDE	3.0E-01	NA	mg/kg
Antimony	1.0E-02	5.4E+00	mg/kg
Aroclor-1221	6.0E-02	NA	mg/kg
Aroclor-1248	6.0E-02	NA	mg/kg
Aroclor-1254	6.0E-02	NA	mg/kg
Aroclor-1260	6.0E-02	NA	mg/kg
Arsenic	1.0E-03	5.1E+00	mg/kg
Barium	1.0E-02	9.7E+01	mg/kg
Beryllium	1.0E-02	7.6E-01	mg/kg
Boron	1.0E-02	1.1E+02	mg/kg
Cadmium	1.0E-02	3.5E+00	mg/kg
Carbazole	3.0E-01	NA	mg/kg
Chromium	1.0E-02	1.6E+01	mg/kg
Cobalt	1.0E-02	1.2E+01	mg/kg
Copper	1.0E-03	2.0E+01	mg/kg

Compound		Concentrati	Units
Cyanide	1.0E-02	2.5E-01	mg/kg
Endrin	3.0E-01	NA	mg/kg
Lead	1.0E-02	2.4E+01	mg/kg
Manganese	1.0E-02	9.8E+02	mg/kg
Mercury	5.0E-02	2.1E-01	mg/kg
Molybdenum	1.0E-02	6.5E+00	mg/kg
Nickel	5.0E-04	2.3E+01	mg/kg
Selenium	1.0E-02	6.3E-01	mg/kg
Silver	1.0E-02	6.0E+00	mg/kg
Tetrachlordibenzo-p-dioxin	3.0E-02	3.5E-08	mg/kg
Thallium	1.0E-02	5.6E-01	mg/kg
Thorium	1.0E-02	NA	mg/kg
Uranium	1.0E-02	NA	mg/kg
Vanadium	1.0E-03	2.6E+01	mg/kg
Zinc	1.0E-02	6.4E+01	mg/kg

References

Table I.IV-6 (continued)
Summary of Risk Characterization (chemicals)
Trespassing Child Current Land Use Scenario (age7-18)
Via Dermal Contact with Soil/Sediment

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	7.4E-07	6.0E-05	1.2E-02
Aroclor-1221	NA	5.3E-05	NA
Aroclor-1248	NA	5.3E-05	NA
Aroclor-1254	NA	5.3E-05	NA
Aroclor-1260	NA	5.3E-05	NA
Arsenic	7.1E-08	2.9E-04	2.5E-04
Barium	1.4E-05	6.4E-02	2.1E-04
Beryllium	1.1E-07	5.0E-05	2.1E-03
Boron	1.6E-05	4.5E-03	3.5E-03
Cadmium	4.8E-07	5.0E-05	9.7E-03
Carbazole	NA	NA	NA
Chromium	2.3E-06	2.3E-03	1.0E-03
Cobalt	1.7E-06	2.7E-02	6.2E-05
Copper	2.8E-07	2.2E-02	1.3E-05
Cyanide	3.5E-08	NA	NA
Endrin	NA	2.7E-04	NA
Lead	3.3E-06	NA	NA
Manganese	1.4E-04	4.2E-03	3.2E-02
Mercury	1.5E-07	4.5E-05	3.3E-03
Molybdenum	9.0E-07	1.9E-03	4.8E-04
Nickel	1.6E-07	2.0E-03	7.9E-05
Selenium	8.8E-08	4.0E-03	2.2E-05
Silver	8.4E-07	NA	NA
Tetrachlordibenzo-p-dioxin	1.5E-14	NA	NA
Thallium	7.8E-08	6.0E-05	1.3E-03
Thorium	NA	NA	NA
Uranium	NA	1.5E-04	NA
Vanadium	3.6E-07	3.5E-04	1.0E-03
Zinc	8.9E-06	7.5E-02	1.2E-04
	HQ Summation =		6.8E-02

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.8E-01	NA
Antimony	1.3E-07	NA	NA
Aroclor-1221	NA	1.0E+01	NA
Aroclor-1248	NA	1.0E+01	NA
Aroclor-1254	NA	1.0E+01	NA
Aroclor-1260	NA	1.0E+01	NA
Arsenic	1.2E-08	1.9E+00	2.3E-08
Barium	2.3E-06	NA	NA
Beryllium	1.8E-08	4.3E+02	7.7E-06
Boron	2.7E-06	NA	NA
Cadmium	8.3E-08	NA	NA
Carbazole	NA	2.2E-02	NA
Chromium	3.9E-07	NA	NA
Cobalt	2.9E-07	NA	NA
Copper	4.8E-08	NA	NA
Cyanide	6.0E-09	NA	NA
Endrin	NA	NA	NA
Lead	5.6E-07	NA	NA
Manganese	2.3E-05	NA	NA
Mercury	2.6E-08	NA	NA
Molybdenum	1.5E-07	NA	NA
Nickel	2.7E-08	NA	NA
Selenium	1.5E-08	NA	NA
Silver	1.4E-07	NA	NA
Tetrachlordibenzo-p-dioxin	2.5E-15	3.0E+05	7.5E-10
Thallium	1.3E-08	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	6.2E-08	NA	NA
Zinc	1.5E-06	NA	NA
	ILCR Summation =		7.8E-06

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Table I.IV–7
Summary of Risk Quantitation (Radionuclides)
Trespassing Child Current Land Use Scenario (age7–18)
Via External Radiation

Exposure Equation = $[CR \times EF \times EDn \times ET_i \times (1-SH_i)] + [CR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.14	(unitless)
ED	Exposure duration	12	Year
ET_i	Fraction of day spent indoors	0	(unitless)
ET_o	Fraction of day spent outdoors	0.17	(unitless)
SH_i	Shield factor indoors	0.5	(unitless)
SH_o	Shield factor outdoors	0	(unitless)
CR	Radionuclide specific concentrations		(see table below)

Cs-137	5.8E-01	pCi/g	Ru-106	1.3E-01	pCi/g
Np-237	8.4E-02	pCi/g	Sr-90	8.3E-01	pCi/g
Pa-231	NA	pCi/g	Tc-99	1.9E+00	pCi/g
Pb-210	1.1E+00	pCi/g	Th-228	4.0E-01	pCi/g
Pu-238	9.1E-02	pCi/g	Th-230	5.9E-02	pCi/g
Pu-239	1.3E-02	pCi/g	Th-232	NA	pCi/g
Pu-240	4.6E-02	pCi/g	U-234	2.1E+01	pCi/g
Ra-226	4.0E-01	pCi/g	U-235	9.3E-01	pCi/g
Ra-228	7.0E-01	pCi/g	U-236	6.9E+00	pCi/g
Rn-222	NA	pCi/g	U-238	1.4E+01	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs-137	1.7E-01	2.0E-06	3.3E-07
Np-237	2.4E-02	4.3E-07	1.0E-08
Pa-231	NA	2.6E-08	NA
Pb-210	3.0E-01	1.6E-10	4.8E-11
Pu-238	2.6E-02	2.8E-11	7.3E-13
Pu-239	3.6E-03	1.7E-11	6.1E-14
Pu-240	1.3E-02	2.7E-11	3.5E-13
Ra-226	1.1E-01	6.0E-06	6.8E-07
Ra-228	2.0E-01	2.9E-06	5.8E-07
Rn-222	NA	5.9E-06	NA
Ru-106	3.8E-02	NA	NA
Sr-90	2.4E-01	NA	NA
Tc-99	5.3E-01	6.0E-13	3.2E-13
Th-228	1.1E-01	5.6E-06	6.4E-07
Th-230	1.7E-02	5.4E-11	9.1E-13
Th-232	NA	2.6E-11	NA
U-234	5.9E+00	3.0E-11	1.8E-10
U-235	2.7E-01	2.4E-07	6.4E-08
U-236	2.0E+00	2.4E-11	4.7E-11
U-238	3.9E+00	3.6E-08	1.4E-07
		ILCR Summation =	2.5E-06

Table I.IV-8
Summary of Intake Quantitation (Chemicals)
Groundskeeper Current Land Use Scenario
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	2.5	m^3/hour
ET	Exposure time	8	hours/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 x 365)	9125	days
CS	Concentration of chemicals in particulate as modeled		(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3
4,4-DDE	1.0E-09	mg/m^3
Antimony	5.5E-07	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3
Arsenic	5.3E-07	mg/m^3
Barium	8.7E-06	mg/m^3
Beryllium	6.0E-08	mg/m^3
Boron	1.1E-05	mg/m^3
Cadmium	3.7E-07	mg/m^3
Carbazole	7.3E-09	mg/m^3
Chromium	1.2E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3
Copper	2.0E-06	mg/m^3

Compound	Concentration	Units
Cyanide	2.3E-08	mg/m^3
Endrin	1.5E-10	mg/m^3
Lead	2.1E-06	mg/m^3
Manganese	7.7E-05	mg/m^3
Mercury	2.8E-08	mg/m^3
Molybdenum	5.4E-07	mg/m^3
Nickel	1.8E-06	mg/m^3
Selenium	6.5E-08	mg/m^3
Silver	6.5E-07	mg/m^3
Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Thallium	4.4E-08	mg/m^3
Thorium	2.3E-06	mg/m^3
Uranium	5.8E-05	mg/m^3
Vanadium	2.1E-06	mg/m^3
Zinc	6.3E-06	mg/m^3

References

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Table I.IV-8 (continued)
Summary of Risk Characterization (Chemicals)
Groundskeeper Current Land Use Scenario
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	7.7E-10	NA	NA
4,4-DDE	2.0E-10	NA	NA
Antimony	1.1E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	6.7E-09	NA	NA
Aroclor-1260	3.8E-09	NA	NA
Arsenic	1.0E-07	NA	NA
Barium	1.7E-06	1.0E-04	1.7E-02
Beryllium	1.2E-08	NA	NA
Boron	2.2E-06	5.7E-03	3.8E-04
Cadmium	7.3E-08	NA	NA
Carbazole	1.4E-09	NA	NA
Chromium	2.4E-07	NA	NA
Cobalt	1.8E-07	3.0E-07	6.1E-01
Copper	4.0E-07	NA	NA
Cyanide	4.5E-09	NA	NA
Endrin	2.9E-11	NA	NA
Lead	4.1E-07	NA	NA
Manganese	1.5E-05	1.1E-04	1.4E-01
Mercury	5.4E-09	8.6E-05	6.3E-05
Molybdenum	1.1E-07	NA	NA
Nickel	3.5E-07	NA	NA
Selenium	1.3E-08	NA	NA
Silver	1.3E-07	NA	NA
Tetrachlordibenzo-p-dioxin	4.0E-15	NA	NA
Thallium	8.6E-09	NA	NA
Thorium	4.5E-07	NA	NA
Uranium	1.1E-05	NA	NA
Vanadium	4.1E-07	NA	NA
Zinc	1.2E-06	NA	NA
	HQ Summation =		7.6E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	2.7E-10	NA	NA
4,4-DDE	7.2E-11	NA	NA
Antimony	3.8E-08	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.4E-09	NA	NA
Aroclor-1260	1.3E-09	NA	NA
Arsenic	3.7E-08	1.5E+01	5.6E-07
Barium	6.1E-07	NA	NA
Beryllium	4.2E-09	8.4E+00	3.5E-08
Boron	7.8E-07	NA	NA
Cadmium	2.6E-08	6.1E+00	1.6E-07
Carbazole	5.1E-10	NA	NA
Chromium	8.5E-08	4.1E+01	3.5E-06
Cobalt	6.5E-08	NA	NA
Copper	1.4E-07	NA	NA
Cyanide	1.6E-09	NA	NA
Endrin	1.0E-11	NA	NA
Lead	1.5E-07	NA	NA
Manganese	5.4E-06	NA	NA
Mercury	1.9E-09	NA	NA
Molybdenum	3.8E-08	NA	NA
Nickel	1.2E-07	8.4E-01	1.0E-07
Selenium	4.6E-09	NA	NA
Silver	4.5E-08	NA	NA
Tetrachlordibenzo-p-dioxin	1.4E-15	1.5E+05	2.2E-10
Thallium	3.1E-09	NA	NA
Thorium	1.6E-07	NA	NA
Uranium	4.1E-06	NA	NA
Vanadium	1.5E-07	NA	NA
Zinc	4.4E-07	NA	NA
	ILCR Summation =		4.4E-06

Table I.IV–9
Summary of Intake and Risk Quantitation (Radionuclides)
Groundskeeper Current Land Use Scenario
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X ET X IR

IR	Inhalation rate of gases (RAGS, 1989)	2.5 m^3/hour
EF	Exposure frequency	250 days/year
EDn	Exposure duration	25 Year
ET	Exposure time	8 hours/day
Ca	Concentration of radionuclides in air	(see table below)

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	6.0E+00	1.9E-11	1.1E-10
Np-237	2.4E+00	2.9E-08	7.1E-08
Pa-231	2.5E+00	3.6E-08	9.0E-08
Pb-210	1.0E+01	4.0E-09	4.1E-08
Pu-238	3.8E+00	3.9E-08	1.5E-07
Pu-239	9.5E-01	3.8E-08	3.6E-08
Pu-240	3.5E+00	3.8E-08	1.3E-07
Ra-226	3.9E+00	3.0E-09	1.2E-08
Ra-228	6.9E+00	6.9E-10	4.7E-09
Rn-222	3.3E+05	7.7E-12	2.6E-06
Ru-106	1.0E+00	4.4E-10	4.6E-10
Sr-90	1.0E+01	6.2E-11	6.2E-10
Tc-99	4.8E+01	8.3E-12	4.0E-10
Th-228	4.5E+00	7.8E-08	3.5E-07
Th-230	3.2E+01	2.9E-08	9.4E-07
Th-232	1.2E+01	2.8E-08	3.3E-07
U-234	3.0E+02	2.6E-08	7.8E-06
U-235	1.2E+01	2.5E-08	3.0E-07
U-236	7.2E+01	2.5E-08	1.8E-06
U-238	1.5E+02	5.2E-11	7.8E-09
		ILCR Summation =	1.5E-05

Table I.IV-10
Summary of Intake Quantitation (Chemicals)
Groundskeeper Current Land Use Scenario
Via Incidental Ingestion of Soil/Sediment

Intake 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	1.00E-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 x 365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/kg
4,4-DDE	NA	mg/kg
Antimony	5.4E+00	mg/kg
Aroclor-1221	NA	mg/kg
Aroclor-1248	NA	mg/kg
Aroclor-1254	NA	mg/kg
Aroclor-1260	NA	mg/kg
Arsenic	5.1E+00	mg/kg
Barium	9.7E+01	mg/kg
Beryllium	7.6E-01	mg/kg
Boron	1.1E+02	mg/kg
Cadmium	3.5E+00	mg/kg
Carbazole	NA	mg/kg
Chromium	1.6E+01	mg/kg
Cobalt	1.2E+01	mg/kg
Copper	2.0E+01	mg/kg

Compound	Concentration	Units
Cyanide	2.5E-01	mg/kg
Endrin	NA	mg/kg
Lead	2.4E+01	mg/kg
Manganese	9.8E+02	mg/kg
Mercury	2.1E-01	mg/kg
Molybdenum	6.5E+00	mg/kg
Nickel	2.3E+01	mg/kg
Selenium	6.3E-01	mg/kg
Silver	6.0E+00	mg/kg
Tetrachlordibenzo-p-dioxin	3.5E-08	mg/kg
Thallium	5.6E-01	mg/kg
Thorium	NA	mg/kg
Uranium	NA	mg/kg
Vanadium	2.6E+01	mg/kg
Zinc	6.4E+01	mg/kg

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Table I.IV-10 (continued)
Summary of Risk Characterization (Chemicals)
Groundskeeper Current Land Use Scenario
Via Incidental Ingestion of Soil/Sediment

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	5.2E-06	4.0E-04	1.3E-02
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	5.0E-06	3.0E-04	1.7E-02
Barium	9.5E-05	7.0E-02	1.4E-03
Beryllium	7.4E-07	5.0E-03	1.5E-04
Boron	1.1E-04	9.0E-02	1.2E-03
Cadmium	3.4E-06	1.0E-03	3.4E-03
Carbazole	NA	NA	NA
Chromium	1.6E-05	5.0E-03	3.2E-03
Cobalt	1.2E-05	6.0E-02	2.0E-04
Copper	2.0E-05	NA	NA
Cyanide	2.4E-07	2.0E-02	1.2E-05
Endrin	NA	3.0E-04	NA
Lead	2.3E-05	NA	NA
Manganese	9.5E-04	1.4E-01	6.8E-03
Mercury	2.1E-07	3.0E-04	7.0E-04
Molybdenum	6.4E-06	5.0E-03	1.3E-03
Nickel	2.2E-05	2.0E-02	1.1E-03
Selenium	6.2E-07	5.0E-03	1.2E-04
Silver	5.9E-06	5.0E-03	1.2E-03
Tetrachlordibenzo-p-dioxin	3.4E-14	NA	NA
Thallium	5.5E-07	8.0E-05	6.8E-03
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	NA
Vanadium	2.5E-05	7.0E-03	3.6E-03
Zinc	6.3E-05	3.0E-01	2.1E-04
	HQ Summation =		6.1E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	1.9E-06	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	1.8E-06	1.8E+00	3.2E-06
Barium	3.4E-05	NA	NA
Beryllium	2.6E-07	4.3E+00	1.1E-06
Boron	3.9E-05	NA	NA
Cadmium	1.2E-06	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	5.7E-06	NA	NA
Cobalt	4.2E-06	NA	NA
Copper	7.1E-06	NA	NA
Cyanide	8.7E-08	NA	NA
Endrin	NA	NA	NA
Lead	8.2E-06	NA	NA
Manganese	3.4E-04	NA	NA
Mercury	7.5E-08	NA	NA
Molybdenum	2.3E-06	NA	NA
Nickel	7.9E-06	NA	NA
Selenium	2.2E-07	NA	NA
Silver	2.1E-06	NA	NA
Tetrachlordibenzo-p-dioxin	1.2E-14	1.5E+05	1.8E-09
Thallium	1.9E-07	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	9.1E-06	NA	NA
Zinc	2.2E-05	NA	NA
	ILCR Summation =		4.3E-06

Table I.IV-11
Summary of Intake and Risk Quantitation (Radionuclides)
Groundskeeper Current Land Use Scenario
Via Incidental Ingestion of Soil/Sediment

Intake 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	(see table below)

Cs-137	5.8E-04	pCi/mg	Ru-106	1.3E-04	pCi/mg
Np-237	8.4E-05	pCi/mg	Sr-90	8.3E-04	pCi/mg
Pa-231	NA	pCi/mg	Tc-99	1.9E-03	pCi/mg
Pb-210	1.1E-03	pCi/mg	Th-228	4.0E-04	pCi/mg
Pu-238	9.1E-05	pCi/mg	Th-230	5.9E-05	pCi/mg
Pu-239	1.3E-05	pCi/mg	Th-232	6.0E-04	pCi/mg
Pu-240	4.6E-05	pCi/mg	U-234	2.1E-02	pCi/mg
Ra-226	4.0E-04	pCi/mg	U-235	9.3E-04	pCi/mg
Ra-228	7.0E-04	pCi/mg	U-236	6.9E-03	pCi/mg
Rn-222	NA	pCi/mg	U-238	1.4E-02	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	3.7E+02	2.8E-11	1.0E-08
Np-237	5.2E+01	2.2E-10	1.1E-08
Pa-231	NA	9.2E-11	NA
Pb-210	6.6E+02	6.6E-10	4.3E-07
Pu-238	5.7E+01	2.2E-10	1.2E-08
Pu-239	7.8E+00	2.3E-10	1.8E-09
Pu-240	2.8E+01	2.3E-10	6.5E-09
Ra-226	2.5E+02	1.2E-10	3.0E-08
Ra-228	4.4E+02	1.0E-10	4.4E-08
Rn-222	NA	1.7E-12	NA
Ru-106	8.3E+01	9.5E-12	7.9E-10
Sr-90	5.2E+02	3.6E-11	1.9E-08
Tc-99	1.2E+03	1.3E-12	1.5E-09
Th-228	2.5E+02	5.5E-11	1.4E-08
Th-230	3.7E+01	1.3E-11	4.8E-10
Th-232	3.7E+02	1.2E-11	4.5E-09
U-234	1.3E+04	1.6E-11	2.1E-07
U-235	5.8E+02	1.6E-11	9.3E-09
U-236	4.3E+03	1.5E-11	6.4E-08
U-238	8.6E+03	2.8E-11	2.4E-07
		ILCR Summation =	1.1E-06

Table 1.IV-12
Summary of Intake Quantitation (Chemicals)
Groundskeeper Current Land Use Scenario
Via Dermal Contact with Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

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	Chemical specific absorbtion factor (see table below)	csv
CF	Conversion factor	1.00E-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 x 365)	9125 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	ABS	Concentrati	Units
2-Methylnaphthalene	3.0E-01	NA	mg/kg
4,4-DDE	3.0E-01	NA	mg/kg
Antimony	1.0E-02	5.4E+00	mg/kg
Aroclor-1221	6.0E-02	NA	mg/kg
Aroclor-1248	6.0E-02	NA	mg/kg
Aroclor-1254	6.0E-02	NA	mg/kg
Aroclor-1260	6.0E-02	NA	mg/kg
Arsenic	1.0E-03	5.1E+00	mg/kg
Barium	1.0E-02	9.7E+01	mg/kg
Beryllium	1.0E-02	7.6E-01	mg/kg
Boron	1.0E-02	1.1E+02	mg/kg
Cadmium	1.0E-02	3.5E+00	mg/kg
Carbazole	3.0E-01	NA	mg/kg
Chromium	1.0E-02	1.6E+01	mg/kg
Cobalt	1.0E-02	1.2E+01	mg/kg
Copper	1.0E-03	2.0E+01	mg/kg

Compound	ABS	Concentrati	Units
Cyanide	1.0E-02	2.5E-01	mg/kg
Endrin	3.0E-01	NA	mg/kg
Lead	1.0E-02	2.4E+01	mg/kg
Manganese	1.0E-02	9.8E+02	mg/kg
Mercury	5.0E-02	2.1E-01	mg/kg
Molybdenum	1.0E-02	6.5E+00	mg/kg
Nickel	5.0E-04	2.3E+01	mg/kg
Selenium	1.0E-02	6.3E-01	mg/kg
Silver	1.0E-02	6.0E+00	mg/kg
Tetrachlordibenzo-p-dioxin	3.0E-02	3.5E-08	mg/kg
Thallium	1.0E-02	5.6E-01	mg/kg
Thorium	1.0E-02	NA	mg/kg
Uranium	1.0E-02	NA	mg/kg
Vanadium	1.0E-03	2.6E+01	mg/kg
Zinc	1.0E-02	6.4E+01	mg/kg

References

Table I.IV-12 (continued)
Summary of Risk Characterization (Chemicals)
Groundskeeper Current Land Use Scenario
Via Dermal Contact with Soil/Sediment

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	3.0E-06	6.0E-05	5.0E-02
Aroclor-1221	NA	5.3E-05	NA
Aroclor-1248	NA	5.3E-05	NA
Aroclor-1254	NA	5.3E-05	NA
Aroclor-1260	NA	5.3E-05	NA
Arsenic	2.9E-07	2.9E-04	1.0E-03
Barium	5.5E-05	6.4E-02	8.6E-04
Beryllium	4.2E-07	5.0E-05	8.5E-03
Boron	6.3E-05	4.5E-03	1.4E-02
Cadmium	2.0E-06	5.0E-05	3.9E-02
Carbazole	NA	NA	NA
Chromium	9.2E-06	2.3E-03	4.1E-03
Cobalt	6.8E-06	2.7E-02	2.5E-04
Copper	1.1E-06	2.2E-02	5.2E-05
Cyanide	1.4E-07	NA	NA
Endrin	NA	2.7E-04	NA
Lead	1.3E-05	NA	NA
Manganese	5.5E-04	4.2E-03	1.3E-01
Mercury	6.0E-07	4.5E-05	1.3E-02
Molybdenum	3.7E-06	1.9E-03	1.9E-03
Nickel	6.4E-07	2.0E-03	3.2E-04
Selenium	3.6E-07	4.0E-03	8.9E-05
Silver	3.4E-06	NA	NA
Tetrachlordibenzo-p-dioxin	5.9E-14	NA	NA
Thallium	3.1E-07	6.0E-05	5.2E-03
Thorium	NA	NA	NA
Uranium	NA	1.5E-04	NA
Vanadium	1.5E-06	3.5E-04	4.2E-03
Zinc	3.6E-05	7.5E-02	4.8E-04
	HQ Summation =		2.7E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.8E-01	NA
Antimony	1.1E-06	NA	NA
Aroclor-1221	NA	1.0E+01	NA
Aroclor-1248	NA	1.0E+01	NA
Aroclor-1254	NA	1.0E+01	NA
Aroclor-1260	NA	1.0E+01	NA
Arsenic	1.0E-07	1.9E+00	1.9E-07
Barium	2.0E-05	NA	NA
Beryllium	1.5E-07	4.3E+02	6.5E-05
Boron	2.3E-05	NA	NA
Cadmium	7.0E-07	NA	NA
Carbazole	NA	2.2E-02	NA
Chromium	3.3E-06	NA	NA
Cobalt	2.4E-06	NA	NA
Copper	4.1E-07	NA	NA
Cyanide	5.0E-08	NA	NA
Endrin	NA	NA	NA
Lead	4.7E-06	NA	NA
Manganese	2.0E-04	NA	NA
Mercury	2.2E-07	NA	NA
Molybdenum	1.3E-06	NA	NA
Nickel	2.3E-07	NA	NA
Selenium	1.3E-07	NA	NA
Silver	1.2E-06	NA	NA
Tetrachlordibenzo-p-dioxin	2.1E-14	3.0E+05	6.3E-09
Thallium	1.1E-07	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	5.2E-07	NA	NA
Zinc	1.3E-05	NA	NA
	ILCR Summation =		6.5E-05

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Table I.IV-13
Summary of Risk Quantitation (Radionuclides)
Groundskeeper Current Land Use Scenario
Via External Radiation

Exposure Equation = $[CR \times EF \times ED_n \times ET_i \times (1-SH_i)] + [CR \times EF \times ED_n \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.68 (unitless)
ED	Exposure duration	25 Year
ET_i	Fraction of day spent indoors	0 (unitless)
ET_o	Fraction of day spent outdoors (8hours/24hours)	0.33 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	0 (unitless)
CR	Radionuclide specific concentrations	(see table below)

Cs-137	5.8E-01	pCi/g	Ru-106	1.3E-01 pCi/g
Np-237	8.4E-02	pCi/g	Sr-90	8.3E-01 pCi/g
Pa-231	NA	pCi/g	Tc-99	1.9E+00 pCi/g
Pb-210	1.1E+00	pCi/g	Th-228	4.0E-01 pCi/g
Pu-238	9.1E-02	pCi/g	Th-230	5.9E-02 pCi/g
Pu-239	1.3E-02	pCi/g	Th-232	NA pCi/g
Pu-240	4.6E-02	pCi/g	U-234	2.1E+01 pCi/g
Ra-226	4.0E-01	pCi/g	U-235	9.3E-01 pCi/g
Ra-228	7.0E-01	pCi/g	U-236	6.9E+00 pCi/g
Rn-222	NA	pCi/g	U-238	1.4E+01 pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs-137	3.3E+00	2.0E-06	6.6E-06
Np-237	4.7E-01	4.3E-07	2.0E-07
Pa-231	NA	2.6E-08	NA
Pb-210	5.9E+00	1.6E-10	9.4E-10
Pu-238	5.1E-01	2.8E-11	1.4E-11
Pu-239	7.0E-02	1.7E-11	1.2E-12
Pu-240	2.6E-01	2.7E-11	6.9E-12
Ra-226	2.2E+00	6.0E-06	1.3E-05
Ra-228	3.9E+00	2.9E-06	1.1E-05
Rn-222	NA	5.9E-06	NA
Ru-106	7.5E-01	NA	NA
Sr-90	4.7E+00	NA	NA
Tc-99	1.0E+01	6.0E-13	6.3E-12
Th-228	2.2E+00	5.6E-06	1.3E-05
Th-230	3.3E-01	5.4E-11	1.8E-11
Th-232	NA	2.6E-11	NA
U-234	1.2E+02	3.0E-11	3.5E-09
U-235	5.2E+00	2.4E-07	1.3E-06
U-236	3.8E+01	2.4E-11	9.2E-10
U-238	7.7E+01	3.6E-08	2.8E-06
		ILCR Summation =	4.8E-05

Table I.IV-14
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
Via Inhalation of Particulates

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Intake 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 x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3	Cyanide	2.3E-08	mg/m^3
4,4-DDE	1.0E-09	mg/m^3	Endrin	1.5E-10	mg/m^3
Antimony	5.5E-07	mg/m^3	Lead	2.1E-06	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3	Manganese	7.7E-05	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3	Mercury	2.8E-08	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3	Molybdenum	5.4E-07	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3	Nickel	1.8E-06	mg/m^3
Arsenic	5.3E-07	mg/m^3	Selenium	6.5E-08	mg/m^3
Barium	8.7E-06	mg/m^3	Silver	6.5E-07	mg/m^3
Beryllium	6.0E-08	mg/m^3	Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Boron	1.1E-05	mg/m^3	Thallium	4.4E-08	mg/m^3
Cadmium	3.7E-07	mg/m^3	Thorium	2.3E-06	mg/m^3
Carbazole	7.3E-09	mg/m^3	Uranium	5.8E-05	mg/m^3
Chromium	1.2E-06	mg/m^3	Vanadium	2.1E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3	Zinc	6.3E-06	mg/m^3
Copper	2.0E-06	mg/m^3			

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Table I.IV-14 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	1.1E-09	NA	NA
4,4-DDE	2.8E-10	NA	NA
Antimony	1.5E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.4E-09	NA	NA
Aroclor-1260	5.3E-09	NA	NA
Arsenic	1.5E-07	NA	NA
Barium	2.4E-06	1.0E-04	2.4E-02
Beryllium	1.6E-08	NA	NA
Boron	3.0E-06	5.7E-03	5.3E-04
Cadmium	1.0E-07	NA	NA
Carbazole	2.0E-09	NA	NA
Chromium	3.3E-07	NA	NA
Cobalt	2.6E-07	3.0E-07	8.5E-01
Copper	5.6E-07	NA	NA
Cyanide	6.3E-09	NA	NA
Endrin	4.0E-11	NA	NA
Lead	5.8E-07	NA	NA
Manganese	2.1E-05	1.1E-04	1.9E-01
Mercury	7.6E-09	8.6E-05	8.8E-05
Molybdenum	1.5E-07	NA	NA
Nickel	4.9E-07	NA	NA
Selenium	1.8E-08	NA	NA
Silver	1.8E-07	NA	NA
Tetrachlordibenzo-p-dioxin	5.6E-15	NA	NA
Thallium	1.2E-08	NA	NA
Thorium	6.3E-07	NA	NA
Uranium	1.6E-05	NA	NA
Vanadium	5.8E-07	NA	NA
Zinc	1.7E-06	NA	NA
	Hazard Quotient Sum =		1.1E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	1.1E-09	NA	NA
4,4-DDE	2.8E-10	NA	NA
Antimony	1.5E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.4E-09	NA	NA
Aroclor-1260	5.3E-09	NA	NA
Arsenic	1.5E-07	1.5E+01	2.2E-06
Barium	2.4E-06	NA	NA
Beryllium	1.6E-08	8.4E+00	1.4E-07
Boron	3.0E-06	NA	NA
Cadmium	1.0E-07	6.1E+00	6.3E-07
Carbazole	2.0E-09	NA	NA
Chromium	3.3E-07	4.1E+01	1.4E-05
Cobalt	2.6E-07	NA	NA
Copper	5.6E-07	NA	NA
Cyanide	6.3E-09	NA	NA
Endrin	4.0E-11	NA	NA
Lead	5.8E-07	NA	NA
Manganese	2.1E-05	NA	NA
Mercury	7.6E-09	NA	NA
Molybdenum	1.5E-07	NA	NA
Nickel	4.9E-07	8.4E-01	4.1E-07
Selenium	1.8E-08	NA	NA
Silver	1.8E-07	NA	NA
Tetrachlordibenzo-p-dioxin	5.6E-15	1.5E+05	8.5E-10
Thallium	1.2E-08	NA	NA
Thorium	6.3E-07	NA	NA
Uranium	1.6E-05	NA	NA
Vanadium	5.8E-07	NA	NA
Zinc	1.7E-06	NA	NA
	ILCR Summation =		1.7E-05

Table I.IV-15
Summary of Intake and Risk Quantitation (Radionuclides)
Off-Property RME Resident Farm Adult Current Land Use Scenario
Via Inhalation of Gases and Particulates

Intake 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)

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	2.3E+01	1.9E-11	4.4E-10
Np-237	9.6E+00	2.9E-08	2.8E-07
Pa-231	9.8E+00	3.6E-08	3.5E-07
Pb-210	4.1E+01	4.0E-09	1.6E-07
Pu-238	1.5E+01	3.9E-08	5.8E-07
Pu-239	3.7E+00	3.8E-08	1.4E-07
Pu-240	1.4E+01	3.8E-08	5.1E-07
Ra-226	1.5E+01	3.0E-09	4.6E-08
Ra-228	2.7E+01	6.9E-10	1.9E-08
Rn-222	1.3E+06	7.7E-12	1.0E-05
Ru-106	4.1E+00	4.4E-10	1.8E-09
Sr-90	3.9E+01	6.2E-11	2.4E-09
Tc-99	1.9E+02	8.3E-12	1.6E-09
Th-228	1.8E+01	7.8E-08	1.4E-06
Th-230	1.3E+02	2.9E-08	3.7E-06
Th-232	4.6E+01	2.8E-08	1.3E-06
U-234	1.2E+03	2.6E-08	3.0E-05
U-235	4.8E+01	2.5E-08	1.2E-06
U-236	2.8E+02	2.5E-08	7.1E-06
U-238	5.9E+02	5.2E-11	3.1E-08
		ILCR Summation =	5.7E-05

Table I.IV-16
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
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
2-Methylnaphthalene	NA	mg/l
4,4-DDE	NA	mg/l
Antimony	3.1E-07	mg/l
Aroclor-1221	2.2E-34	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	NA	mg/l
Aroclor-1260	NA	mg/l
Arsenic	NA	mg/l
Barium	NA	mg/l
Beryllium	NA	mg/l
Boron	NA	mg/l
Cadmium	4.1E-31	mg/l
Carbazole	NA	mg/l
Chromium	NA	mg/l
Cobalt	NA	mg/l
Copper	NA	mg/l

Compound	Concentration	Units
Cyanide	NA	mg/l
Endrin	NA	mg/l
Lead	NA	mg/l
Manganese	NA	mg/l
Mercury	NA	mg/l
Molybdenum	NA	mg/l
Nickel	NA	mg/l
Selenium	NA	mg/l
Silver	NA	mg/l
Tetrachlordibenzo-p-dioxin	NA	mg/l
Thallium	NA	mg/l
Thorium	NA	mg/l
Uranium	NA	mg/l
Vanadium	NA	mg/l
Zinc	NA	mg/l

References

Table I.IV-16
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	8.4E-09	4.0E-04	2.1E-05
Aroclor-1221	6.1E-36	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	NA	3.0E-04	0.0E+00
Barium	NA	7.0E-02	0.0E+00
Beryllium	NA	5.0E-03	0.0E+00
Boron	NA	9.0E-02	0.0E+00
Cadmium	1.1E-32	1.0E-03	1.1E-29
Carbazole	NA	NA	NA
Chromium	NA	5.0E-03	0.0E+00
Cobalt	NA	6.0E-02	0.0E+00
Copper	NA	NA	NA
Cyanide	NA	2.0E-02	0.0E+00
Endrin	NA	3.0E-04	0.0E+00
Lead	NA	NA	NA
Manganese	NA	1.4E-01	0.0E+00
Mercury	NA	3.0E-04	0.0E+00
Molybdenum	NA	5.0E-03	0.0E+00
Nickel	NA	2.0E-02	0.0E+00
Selenium	NA	5.0E-03	0.0E+00
Silver	NA	5.0E-03	0.0E+00
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	NA	8.0E-05	0.0E+00
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	0.0E+00
Vanadium	NA	7.0E-03	0.0E+00
Zinc	NA	3.0E-01	0.0E+00
	HQ Summation =		2.1E-05

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	8.4E-09	NA	0.0E+00
Aroclor-1221	6.1E-36	7.7E+00	4.7E-35
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	NA	1.8E+00	NA
Barium	NA	NA	NA
Beryllium	NA	4.3E+00	NA
Boron	NA	NA	NA
Cadmium	1.1E-32	NA	0.0E+00
Carbazole	NA	2.0E-02	NA
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	NA	NA	NA
Cyanide	NA	NA	NA
Endrin	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Molybdenum	NA	NA	NA
Nickel	NA	NA	NA
Selenium	NA	NA	NA
Silver	NA	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	NA	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	NA	NA	NA
	ILCR Summation =		4.7E-35

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Table I.IV–17
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Current Land Use Scenario
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)

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	7.7E-03	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	4.1E+02	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	9.3E+00	pCi/l
Ra-226	NA	pCi/l	U-235	2.5E-01	pCi/l
Ra-228	NA	pCi/l	U-236	1.0E-01	pCi/l
Rn-222	NA	pCi/l	U-238	5.5E+00	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	3.8E+02	2.2E-10	8.3E-08
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	2.0E+07	1.3E-12	2.6E-05
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	4.5E+05	1.6E-11	7.3E-06
U-235	1.2E+04	1.6E-11	1.9E-07
U-236	4.9E+03	1.5E-11	7.4E-08
U-238	2.7E+05	2.8E-11	7.6E-06
		ILCR Summation =	4.1E-05

Table I.IV-18
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
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	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (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
2-Methylnaphthalene	0.0E+00	mg/kg	Cyanide	1.4E-14	mg/kg
4,4-DDE	5.3E-10	mg/kg	Endrin	1.8E-11	mg/kg
Antimony	2.1E-08	mg/kg	Lead	6.7E-09	mg/kg
Aroclor-1221	0.0E+00	mg/kg	Manganese	3.2E-07	mg/kg
Aroclor-1248	0.0E+00	mg/kg	Mercury	7.6E-08	mg/kg
Aroclor-1254	9.6E-09	mg/kg	Molybdenum	3.4E-08	mg/kg
Aroclor-1260	6.5E-09	mg/kg	Nickel	1.1E-07	mg/kg
Arsenic	1.1E-08	mg/kg	Selenium	1.0E-08	mg/kg
Barium	1.4E-08	mg/kg	Silver	2.1E-08	mg/kg
Beryllium	6.2E-10	mg/kg	Tetrachlordibenzo-p-dioxin	0.0E+00	mg/kg
Boron	1.1E-07	mg/kg	Thallium	1.8E-08	mg/kg
Cadmium	2.4E-09	mg/kg	Thorium	0.0E+00	mg/kg
Carbazole	0.0E+00	mg/kg	Uranium	1.2E-07	mg/kg
Chromium	7.0E-08	mg/kg	Vanadium	5.5E-08	mg/kg
Cobalt	1.9E-07	mg/kg	Zinc	9.0E-06	mg/kg
Copper	2.2E-07	mg/kg			

References

Table I.IV-18 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	5.4E-13	NA	NA
Antimony	2.2E-11	4.0E-04	5.4E-08
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.9E-12	NA	NA
Aroclor-1260	6.7E-12	NA	NA
Arsenic	1.2E-11	3.0E-04	3.9E-08
Barium	1.5E-11	7.0E-02	2.1E-10
Beryllium	6.4E-13	5.0E-03	1.3E-10
Boron	1.2E-10	9.0E-02	1.3E-09
Cadmium	2.5E-12	1.0E-03	2.5E-09
Carbazole	NA	NA	NA
Chromium	7.2E-11	5.0E-03	1.4E-08
Cobalt	2.0E-10	6.0E-02	3.3E-09
Copper	2.2E-10	NA	NA
Cyanide	1.4E-17	2.0E-02	7.0E-16
Endrin	1.9E-14	3.0E-04	6.3E-11
Lead	6.8E-12	NA	NA
Manganese	3.3E-10	1.4E-01	2.4E-09
Mercury	7.8E-11	3.0E-04	2.6E-07
Molybdenum	3.5E-11	5.0E-03	7.1E-09
Nickel	1.2E-10	2.0E-02	5.8E-09
Selenium	1.1E-11	5.0E-03	2.1E-09
Silver	2.1E-11	5.0E-03	4.2E-09
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	1.9E-11	8.0E-05	2.4E-07
Thorium	NA	NA	NA
Uranium	1.3E-10	3.0E-03	4.2E-08
Vanadium	5.7E-11	7.0E-03	8.1E-09
Zinc	9.3E-09	3.0E-01	3.1E-08
	HQ Summation =		7.1E-07

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	5.4E-13	3.4E-01	1.8E-13
Antimony	2.2E-11	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	9.9E-12	7.7E+00	7.6E-11
Aroclor-1260	6.7E-12	7.7E+00	5.2E-11
Arsenic	1.2E-11	1.8E+00	2.1E-11
Barium	1.5E-11	NA	NA
Beryllium	6.4E-13	4.3E+00	2.8E-12
Boron	1.2E-10	NA	NA
Cadmium	2.5E-12	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	7.2E-11	NA	NA
Cobalt	2.0E-10	NA	NA
Copper	2.2E-10	NA	NA
Cyanide	1.4E-17	NA	NA
Endrin	1.9E-14	NA	NA
Lead	6.8E-12	NA	NA
Manganese	3.3E-10	NA	NA
Mercury	7.8E-11	NA	NA
Molybdenum	3.5E-11	NA	NA
Nickel	1.2E-10	NA	NA
Selenium	1.1E-11	NA	NA
Silver	2.1E-11	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	1.9E-11	NA	NA
Thorium	NA	NA	NA
Uranium	1.3E-10	NA	NA
Vanadium	5.7E-11	NA	NA
Zinc	9.3E-09	NA	NA
	ILCR Summation =		1.5E-10

Table I.IV–19
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Current Land Use Scenario
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs-137	1.0E-05	pCi/kg	Ru-106	0.0E+00	pCi/kg
Np-237	2.1E-05	pCi/kg	Sr-90	NA	pCi/kg
Pa-231	1.7E-05	pCi/kg	Tc-99	NA	pCi/kg
Pb-210	0.0E+00	pCi/kg	Th-228	1.4E-09	pCi/kg
Pu-238	1.6E-10	pCi/kg	Th-230	1.6E-08	pCi/kg
Pu-239	4.0E-11	pCi/kg	Th-232	5.9E-09	pCi/kg
Pu-240	1.4E-10	pCi/kg	U-234	9.3E-02	pCi/kg
Ra-226	5.1E-08	pCi/kg	U-235	2.5E-03	pCi/kg
Ra-228	8.9E-08	pCi/kg	U-236	1.0E-03	pCi/kg
Rn-222	0.0E+00	pCi/kg	U-238	5.5E-02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.9E-02	2.8E-11	5.2E-13
Np-237	3.9E-02	2.2E-10	8.5E-12
Pa-231	3.1E-02	9.2E-11	2.8E-12
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	2.9E-07	2.2E-10	6.4E-17
Pu-239	7.3E-08	2.3E-10	1.7E-17
Pu-240	2.6E-07	2.3E-10	6.1E-17
Ra-226	9.4E-05	1.2E-10	1.1E-14
Ra-228	1.6E-04	1.0E-10	1.6E-14
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	0.0E+00	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	NA	1.3E-12	NA
Th-228	2.6E-06	5.5E-11	1.4E-16
Th-230	3.0E-05	1.3E-11	3.9E-16
Th-232	1.1E-05	1.2E-11	1.3E-16
U-234	1.7E+02	1.6E-11	2.7E-09
U-235	4.5E+00	1.6E-11	7.2E-11
U-236	1.9E+00	1.5E-11	2.8E-11
U-238	1.0E+02	2.8E-11	2.9E-09
		ILCR Summation =	5.7E-09

Table I.IV-20
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
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	0.3 l/day
FI	Fraction ingested from contaminated source	1 (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
2-Methylnaphthalene	0.0E+00	mg/l
4,4-DDE	1.0E-10	mg/l
Antimony	2.4E-09	mg/l
Aroclor-1221	NA	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	3.0E-09	mg/l
Aroclor-1260	2.1E-09	mg/l
Arsenic	3.4E-10	mg/l
Barium	3.3E-08	mg/l
Beryllium	5.6E-13	mg/l
Boron	2.1E-07	mg/l
Cadmium	4.4E-09	mg/l
Carbazole	0.0E+00	mg/l
Chromium	1.9E-08	mg/l
Cobalt	1.9E-08	mg/l
Copper	3.3E-08	mg/l

Compound	Concentration	Units
Cyanide	4.4E-15	mg/l
Endrin	2.7E-12	mg/l
Lead	5.5E-09	mg/l
Manganese	2.8E-07	mg/l
Mercury	1.4E-10	mg/l
Molybdenum	8.6E-09	mg/l
Nickel	1.9E-08	mg/l
Selenium	2.7E-09	mg/l
Silver	1.4E-07	mg/l
Tetrachlordibenzo-p-dioxin	0.0E+00	mg/l
Thallium	9.2E-10	mg/l
Thorium	0.0E+00	mg/l
Uranium	3.7E-07	mg/l
Vanadium	4.4E-10	mg/l
Zinc	9.0E-07	mg/l

References

Table I.IV-20 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.2E-13	NA	NA
Antimony	9.9E-12	4.0E-04	2.5E-08
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.2E-11	NA	NA
Aroclor-1260	8.5E-12	NA	NA
Arsenic	1.4E-12	3.0E-04	4.6E-09
Barium	1.4E-10	7.0E-02	1.9E-09
Beryllium	2.3E-15	5.0E-03	4.6E-13
Boron	8.8E-10	9.0E-02	9.7E-09
Cadmium	1.8E-11	1.0E-03	1.8E-08
Carbazole	NA	NA	NA
Chromium	7.9E-11	5.0E-03	1.6E-08
Cobalt	8.0E-11	6.0E-02	1.3E-09
Copper	1.3E-10	NA	NA
Cyanide	1.8E-17	2.0E-02	9.0E-16
Endrin	1.1E-14	3.0E-04	3.7E-11
Lead	2.3E-11	NA	NA
Manganese	1.2E-09	1.4E-01	8.3E-09
Mercury	5.6E-13	3.0E-04	1.9E-09
Molybdenum	3.5E-11	5.0E-03	7.1E-09
Nickel	7.8E-11	2.0E-02	3.9E-09
Selenium	1.1E-11	5.0E-03	2.2E-09
Silver	5.7E-10	5.0E-03	1.1E-07
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	3.8E-12	8.0E-05	4.7E-08
Thorium	NA	NA	NA
Uranium	1.5E-09	3.0E-03	5.0E-07
Vanadium	1.8E-12	7.0E-03	2.6E-10
Zinc	3.7E-09	3.0E-01	1.2E-08
	HQ Summation =		7.7E-07

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.2E-13	3.4E-01	1.4E-13
Antimony	9.9E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.2E-11	7.7E+00	9.6E-11
Aroclor-1260	8.5E-12	7.7E+00	6.5E-11
Arsenic	1.4E-12	1.8E+00	2.5E-12
Barium	1.4E-10	NA	NA
Beryllium	2.3E-15	4.3E+00	9.9E-15
Boron	8.8E-10	NA	NA
Cadmium	1.8E-11	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	7.9E-11	NA	NA
Cobalt	8.0E-11	NA	NA
Copper	1.3E-10	NA	NA
Cyanide	1.8E-17	NA	NA
Endrin	1.1E-14	NA	NA
Lead	2.3E-11	NA	NA
Manganese	1.2E-09	NA	NA
Mercury	5.6E-13	NA	NA
Molybdenum	3.5E-11	NA	NA
Nickel	7.8E-11	NA	NA
Selenium	1.1E-11	NA	NA
Silver	5.7E-10	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	3.8E-12	NA	NA
Thorium	NA	NA	NA
Uranium	1.5E-09	NA	NA
Vanadium	1.8E-12	NA	NA
Zinc	3.7E-09	NA	NA
	ILCR Summation =		1.6E-10

Table I.IV–21
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Current Land Use Scenario
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.3 l/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs-137	3.6E-06	pCi/l	Ru-106	7.8E-32	pCi/l
Np-237	2.3E-06	pCi/l	Sr-90	1.8E-27	pCi/l
Pa-231	1.0E-07	pCi/l	Tc-99	3.5E-19	pCi/l
Pb-210	0.0E+00	pCi/l	Th-228	1.8E-09	pCi/l
Pu-238	3.2E-11	pCi/l	Th-230	1.3E-08	pCi/l
Pu-239	7.9E-12	pCi/l	Th-232	4.9E-09	pCi/l
Pu-240	2.9E-11	pCi/l	U-234	3.3E-01	pCi/l
Ra-226	1.4E-07	pCi/l	U-235	8.9E-03	pCi/l
Ra-228	2.5E-07	pCi/l	U-236	3.6E-03	pCi/l
Rn-222	0.0E+00	pCi/l	U-238	2.0E-01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	2.6E-02	2.8E-11	7.3E-13
Np-237	1.7E-02	2.2E-10	3.7E-12
Pa-231	7.6E-04	9.2E-11	7.0E-14
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	2.3E-07	2.2E-10	5.1E-17
Pu-239	5.8E-08	2.3E-10	1.3E-17
Pu-240	2.1E-07	2.3E-10	4.9E-17
Ra-226	1.0E-03	1.2E-10	1.2E-13
Ra-228	1.8E-03	1.0E-10	1.8E-13
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	5.7E-28	9.5E-12	5.5E-39
Sr-90	1.3E-23	3.6E-11	4.7E-34
Tc-99	2.6E-15	1.3E-12	3.3E-27
Th-228	1.3E-05	5.5E-11	7.2E-16
Th-230	9.9E-05	1.3E-11	1.3E-15
Th-232	3.6E-05	1.2E-11	4.3E-16
U-234	2.5E+03	1.6E-11	3.9E-08
U-235	6.5E+01	1.6E-11	1.0E-09
U-236	2.7E+01	1.5E-11	4.0E-10
U-238	1.5E+03	2.8E-11	4.1E-08
		ILCR Summation =	8.2E-08

Table I.IV-22
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
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
2-Methylnaphthalene	5.3E-10	mg/kg
4,4-DDE	1.4E-10	mg/kg
Antimony	7.4E-08	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	4.7E-09	mg/kg
Aroclor-1260	2.6E-09	mg/kg
Arsenic	7.3E-08	mg/kg
Barium	1.2E-06	mg/kg
Beryllium	8.1E-09	mg/kg
Boron	1.6E-06	mg/kg
Cadmium	5.2E-08	mg/kg
Carbazole	1.0E-09	mg/kg
Chromium	1.7E-07	mg/kg
Cobalt	1.3E-07	mg/kg
Copper	2.8E-07	mg/kg

Compound	Concentration	Units
Cyanide	3.1E-09	mg/kg
Endrin	2.0E-11	mg/kg
Lead	2.9E-07	mg/kg
Manganese	1.0E-05	mg/kg
Mercury	3.8E-09	mg/kg
Molybdenum	8.1E-08	mg/kg
Nickel	2.4E-07	mg/kg
Selenium	8.9E-09	mg/kg
Silver	8.8E-08	mg/kg
Tetrachlordibenzo-p-dioxin	2.8E-15	mg/kg
Thallium	6.0E-09	mg/kg
Thorium	3.1E-07	mg/kg
Uranium	7.9E-06	mg/kg
Vanadium	2.9E-07	mg/kg
Zinc	9.8E-07	mg/kg

References

Table I.IV-22 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Current Land Use Scenario
Via Ingestion of Vegetables and Fruits

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	1.2E-13	NA	NA
Antimony	6.2E-11	4.0E-04	1.6E-07
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	3.9E-12	NA	NA
Aroclor-1260	2.2E-12	NA	NA
Arsenic	6.1E-11	3.0E-04	2.0E-07
Barium	9.9E-10	7.0E-02	1.4E-08
Beryllium	6.8E-12	5.0E-03	1.4E-09
Boron	1.4E-09	9.0E-02	1.5E-08
Cadmium	4.4E-11	1.0E-03	4.4E-08
Carbazole	8.3E-13	NA	NA
Chromium	1.4E-10	5.0E-03	2.8E-08
Cobalt	1.1E-10	6.0E-02	1.8E-09
Copper	2.3E-10	NA	NA
Cyanide	2.6E-12	2.0E-02	1.3E-10
Endrin	1.7E-14	3.0E-04	5.6E-11
Lead	2.4E-10	NA	NA
Manganese	8.7E-09	1.4E-01	6.2E-08
Mercury	3.2E-12	3.0E-04	1.1E-08
Molybdenum	6.7E-11	5.0E-03	1.3E-08
Nickel	2.0E-10	2.0E-02	1.0E-08
Selenium	7.4E-12	5.0E-03	1.5E-09
Silver	7.4E-11	5.0E-03	1.5E-08
Tetrachlordibenzo-p-dioxin	2.3E-18	NA	NA
Thallium	5.0E-12	8.0E-05	6.2E-08
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	3.0E-03	2.2E-06
Vanadium	2.4E-10	7.0E-03	3.4E-08
Zinc	8.2E-10	3.0E-01	2.7E-09
	HQ Summation =		2.9E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	1.2E-13	3.4E-01	4.0E-14
Antimony	6.2E-11	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	3.9E-12	7.7E+00	3.0E-11
Aroclor-1260	2.2E-12	7.7E+00	1.7E-11
Arsenic	6.1E-11	1.8E+00	1.1E-10
Barium	9.9E-10	NA	NA
Beryllium	6.8E-12	4.3E+00	2.9E-11
Boron	1.4E-09	NA	NA
Cadmium	4.4E-11	NA	NA
Carbazole	8.3E-13	2.0E-02	1.7E-14
Chromium	1.4E-10	NA	NA
Cobalt	1.1E-10	NA	NA
Copper	2.3E-10	NA	NA
Cyanide	2.6E-12	NA	NA
Endrin	1.7E-14	NA	NA
Lead	2.4E-10	NA	NA
Manganese	8.7E-09	NA	NA
Mercury	3.2E-12	NA	NA
Molybdenum	6.7E-11	NA	NA
Nickel	2.0E-10	NA	NA
Selenium	7.4E-12	NA	NA
Silver	7.4E-11	NA	NA
Tetrachlordibenzo-p-dioxin	2.3E-18	1.5E+05	3.5E-13
Thallium	5.0E-12	NA	NA
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	NA	NA
Vanadium	2.4E-10	NA	NA
Zinc	8.2E-10	NA	NA
	ILCR Summation =		1.9E-10

Table I.IV–23
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Current Land Use Scenario
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	

Cs-137	6.5E-06	pCi/kg	Ru-106	4.4E-17	pCi/kg
Np-237	2.7E-06	pCi/kg	Sr-90	4.1E-16	pCi/kg
Pa-231	2.7E-06	pCi/kg	Tc-99	7.5E-08	pCi/kg
Pb-210	1.1E-05	pCi/kg	Th-228	4.8E-06	pCi/kg
Pu-238	4.1E-06	pCi/kg	Th-230	3.5E-05	pCi/kg
Pu-239	1.0E-06	pCi/kg	Th-232	1.3E-05	pCi/kg
Pu-240	3.8E-06	pCi/kg	U-234	4.5E+01	pCi/kg
Ra-226	4.2E-06	pCi/kg	U-235	1.2E+00	pCi/kg
Ra-228	7.3E-06	pCi/kg	U-236	4.9E-01	pCi/kg
Rn-222	3.6E-01	pCi/kg	U-238	2.7E+01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	9.7E-03	2.8E-11	2.7E-13
Np-237	4.0E-03	2.2E-10	8.7E-13
Pa-231	4.0E-03	9.2E-11	3.7E-13
Pb-210	1.7E-02	6.6E-10	1.1E-11
Pu-238	6.1E-03	2.2E-10	1.3E-12
Pu-239	1.5E-03	2.3E-10	3.5E-13
Pu-240	5.6E-03	2.3E-10	1.3E-12
Ra-226	6.2E-03	1.2E-10	7.5E-13
Ra-228	1.1E-02	1.0E-10	1.1E-12
Rn-222	5.4E+02	1.7E-12	9.2E-10
Ru-106	6.6E-14	9.5E-12	6.2E-25
Sr-90	6.1E-13	3.6E-11	2.2E-23
Tc-99	1.1E-04	1.3E-12	1.5E-16
Th-228	7.1E-03	5.5E-11	3.9E-13
Th-230	5.2E-02	1.3E-11	6.8E-13
Th-232	1.9E-02	1.2E-11	2.3E-13
U-234	6.8E+04	1.6E-11	1.1E-06
U-235	1.8E+03	1.6E-11	2.9E-08
U-236	7.4E+02	1.5E-11	1.1E-08
U-238	4.1E+04	2.8E-11	1.1E-06
		ILCR Summation =	2.3E-06

Table I.IV-24
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
Via Inhalation of Particulates

Intake 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 x 365)	2190 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3
4,4-DDE	1.0E-09	mg/m^3
Antimony	5.5E-07	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3
Arsenic	5.3E-07	mg/m^3
Barium	8.7E-06	mg/m^3
Beryllium	6.0E-08	mg/m^3
Boron	1.1E-05	mg/m^3
Cadmium	3.7E-07	mg/m^3
Carbazole	7.3E-09	mg/m^3
Chromium	1.2E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3
Copper	2.0E-06	mg/m^3

Compound	Concentration	Units
Cyanide	2.3E-08	mg/m^3
Endrin	1.5E-10	mg/m^3
Lead	2.1E-06	mg/m^3
Manganese	7.7E-05	mg/m^3
Mercury	2.8E-08	mg/m^3
Molybdenum	5.4E-07	mg/m^3
Nickel	1.8E-06	mg/m^3
Selenium	6.5E-08	mg/m^3
Silver	6.5E-07	mg/m^3
Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Thallium	4.4E-08	mg/m^3
Thorium	2.3E-06	mg/m^3
Uranium	5.8E-05	mg/m^3
Vanadium	2.1E-06	mg/m^3
Zinc	6.3E-06	mg/m^3

References

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Table I.IV-24 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	3.0E-09	NA	NA
4,4-DDE	7.9E-10	NA	NA
Antimony	4.2E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.6E-08	NA	NA
Aroclor-1260	1.5E-08	NA	NA
Arsenic	4.1E-07	NA	NA
Barium	6.7E-06	1.0E-04	6.7E-02
Beryllium	4.6E-08	NA	NA
Boron	8.5E-06	5.7E-03	1.5E-03
Cadmium	2.9E-07	NA	NA
Carbazole	5.6E-09	NA	NA
Chromium	9.4E-07	NA	NA
Cobalt	7.1E-07	3.0E-07	2.4E+00
Copper	1.6E-06	NA	NA
Cyanide	1.8E-08	NA	NA
Endrin	1.1E-10	NA	NA
Lead	1.6E-06	NA	NA
Manganese	5.9E-05	1.1E-04	5.3E-01
Mercury	2.1E-08	8.6E-05	2.5E-04
Molybdenum	4.1E-07	NA	NA
Nickel	1.4E-06	NA	NA
Selenium	5.0E-08	NA	NA
Silver	4.9E-07	NA	NA
Tetrachlordibenzo-p-dioxin	1.6E-14	NA	NA
Thallium	3.4E-08	NA	NA
Thorium	1.8E-06	NA	NA
Uranium	4.5E-05	NA	NA
Vanadium	1.6E-06	NA	NA
Zinc	4.8E-06	NA	NA
	HQ Summation =		3.0E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	2.6E-10	NA	NA
4,4-DDE	6.8E-11	NA	NA
Antimony	3.6E-08	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.2E-09	NA	NA
Aroclor-1260	1.3E-09	NA	NA
Arsenic	3.5E-08	1.5E+01	5.3E-07
Barium	5.7E-07	NA	NA
Beryllium	3.9E-09	8.4E+00	3.3E-08
Boron	7.3E-07	NA	NA
Cadmium	2.5E-08	6.1E+00	1.5E-07
Carbazole	4.8E-10	NA	NA
Chromium	8.0E-08	4.1E+01	3.3E-06
Cobalt	6.1E-08	NA	NA
Copper	1.3E-07	NA	NA
Cyanide	1.5E-09	NA	NA
Endrin	9.7E-12	NA	NA
Lead	1.4E-07	NA	NA
Manganese	5.0E-06	NA	NA
Mercury	1.8E-09	NA	NA
Molybdenum	3.6E-08	NA	NA
Nickel	1.2E-07	8.4E-01	9.8E-08
Selenium	4.3E-09	NA	NA
Silver	4.2E-08	NA	NA
Tetrachlordibenzo-p-dioxin	1.4E-15	1.5E+05	2.0E-10
Thallium	2.9E-09	NA	NA
Thorium	1.5E-07	NA	NA
Uranium	3.8E-06	NA	NA
Vanadium	1.4E-07	NA	NA
Zinc	4.1E-07	NA	NA
	ILCR Summation =		4.1E-06

Table I.IV–25
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Current Land Use Scenario
Via Inhalation of Gases and Particulates

Intake 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	

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.2E+00	1.9E-11	2.3E-11
Np-237	4.9E-01	2.9E-08	1.4E-08
Pa-231	5.0E-01	3.6E-08	1.8E-08
Pb-210	2.1E+00	4.0E-09	8.3E-09
Pu-238	7.6E-01	3.9E-08	3.0E-08
Pu-239	1.9E-01	3.8E-08	7.3E-09
Pu-240	7.0E-01	3.8E-08	2.6E-08
Ra-226	7.9E-01	3.0E-09	2.4E-09
Ra-228	1.4E+00	6.9E-10	9.5E-10
Rn-222	6.7E+04	7.7E-12	5.2E-07
Ru-106	2.1E-01	4.4E-10	9.2E-11
Sr-90	2.0E+00	6.2E-11	1.2E-10
Tc-99	9.8E+00	8.3E-12	8.1E-11
Th-228	9.0E-01	7.8E-08	7.0E-08
Th-230	6.5E+00	2.9E-08	1.9E-07
Th-232	2.4E+00	2.8E-08	6.6E-08
U-234	6.0E+01	2.6E-08	1.6E-06
U-235	2.5E+00	2.5E-08	6.1E-08
U-236	1.5E+01	2.5E-08	3.6E-07
U-238	3.0E+01	5.2E-11	1.6E-09
		ILCR Summation =	2.9E-06

Table I.IV-26
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
Via Drinking Water Ingestion

Intake 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 x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/l	Cyanide	NA	mg/l
4,4-DDE	NA	mg/l	Endrin	NA	mg/l
Antimony	3.05E-07	mg/l	Lead	NA	mg/l
Aroclor-1221	2.21E-34	mg/l	Manganese	NA	mg/l
Aroclor-1248	NA	mg/l	Mercury	NA	mg/l
Aroclor-1254	NA	mg/l	Molybdenum	NA	mg/l
Aroclor-1260	NA	mg/l	Nickel	NA	mg/l
Arsenic	NA	mg/l	Selenium	NA	mg/l
Barium	NA	mg/l	Silver	NA	mg/l
Beryllium	NA	mg/l	Tetrachlordibenzo-p-dioxin	NA	mg/l
Boron	NA	mg/l	Thallium	NA	mg/l
Cadmium	4.07E-31	mg/l	Thorium	NA	mg/l
Carbazole	NA	mg/l	Uranium	NA	mg/l
Chromium	NA	mg/l	Vanadium	NA	mg/l
Cobalt	NA	mg/l	Zinc	NA	mg/l
Copper	NA	mg/l	0	NA	mg/l

References

Table I.IV-26
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
Via Drinking Water Ingestion

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	1.9E-08	4.0E-04	4.9E-05
Aroclor-1221	1.4E-35	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	NA	3.0E-04	0.0E+00
Barium	NA	7.0E-02	0.0E+00
Beryllium	NA	5.0E-03	0.0E+00
Boron	NA	9.0E-02	0.0E+00
Cadmium	2.6E-32	1.0E-03	2.6E-29
Carbazole	NA	NA	NA
Chromium	NA	5.0E-03	0.0E+00
Cobalt	NA	6.0E-02	0.0E+00
Copper	NA	NA	NA
Cyanide	NA	2.0E-02	0.0E+00
Endrin	NA	3.0E-04	0.0E+00
Lead	NA	NA	NA
Manganese	NA	1.4E-01	0.0E+00
Mercury	NA	3.0E-04	0.0E+00
Molybdenum	NA	5.0E-03	0.0E+00
Nickel	NA	2.0E-02	0.0E+00
Selenium	NA	5.0E-03	0.0E+00
Silver	NA	5.0E-03	0.0E+00
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	NA	8.0E-05	0.0E+00
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	0.0E+00
Vanadium	NA	7.0E-03	0.0E+00
Zinc	NA	3.0E-01	0.0E+00
	HQ Summation =		4.9E-05

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	1.7E-09	NA	0.0E+00
Aroclor-1221	1.2E-36	7.7E+00	9.3E-36
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	NA	1.8E+00	NA
Barium	NA	NA	NA
Beryllium	NA	4.3E+00	NA
Boron	NA	NA	NA
Cadmium	2.2E-33	NA	0.0E+00
Carbazole	NA	2.0E-02	NA
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	NA	NA	NA
Cyanide	NA	NA	NA
Endrin	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Molybdenum	NA	NA	NA
Nickel	NA	NA	NA
Selenium	NA	NA	NA
Silver	NA	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	NA	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	NA	NA	NA
	ILCR Summation =		9.3E-36

Table I.IV-27
Summary of Intake and Risk Quantitation (Radionuclides)
Off-Property RME Resident Farm Child Current Land Use Scenario
Via Ingestion of Drinking Water

Intake 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	

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	7.7E-03	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	4.1E+02	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	9.3E+00	pCi/l
Ra-226	NA	pCi/l	U-235	2.5E-01	pCi/l
Ra-228	NA	pCi/l	U-236	1.0E-01	pCi/l
Rn-222	NA	pCi/l	U-238	5.5E+00	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	1.6E+01	2.2E-10	3.5E-09
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	8.5E+05	1.3E-12	1.1E-06
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	1.9E+04	1.6E-11	3.1E-07
U-235	5.2E+02	1.6E-11	8.3E-09
U-236	2.1E+02	1.5E-11	3.2E-09
U-238	1.2E+04	2.8E-11	3.3E-07
		ILCR Summation =	1.8E-06

Table I.IV-28
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
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	0.029 kg/day
FI	Fraction ingested from contaminated source	1 (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 x 365)	2190 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	0.0E+00	mg/kg
4,4-DDE	5.3E-10	mg/kg
Antimony	2.1E-08	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	9.6E-09	mg/kg
Aroclor-1260	6.5E-09	mg/kg
Arsenic	1.1E-08	mg/kg
Barium	1.4E-08	mg/kg
Beryllium	6.2E-10	mg/kg
Boron	1.1E-07	mg/kg
Cadmium	2.4E-09	mg/kg
Carbazole	0.0E+00	mg/kg
Chromium	7.0E-08	mg/kg
Cobalt	1.9E-07	mg/kg
Copper	2.2E-07	mg/kg

Compound	Concentration	Units
Cyanide	1.4E-14	mg/kg
Endrin	1.8E-11	mg/kg
Lead	6.7E-09	mg/kg
Manganese	3.2E-07	mg/kg
Mercury	7.6E-08	mg/kg
Molybdenum	3.4E-08	mg/kg
Nickel	1.1E-07	mg/kg
Selenium	1.0E-08	mg/kg
Silver	2.1E-08	mg/kg
Tetrachlordibenzo-p-dioxin	0.0E+00	mg/kg
Thallium	1.8E-08	mg/kg
Thorium	0.0E+00	mg/kg
Uranium	1.2E-07	mg/kg
Vanadium	5.5E-08	mg/kg
Zinc	9.0E-06	mg/kg

References

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Table I.IV-28 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
Via Ingestion of Meat Products

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	9.8E-13	NA	NA
Antimony	3.9E-11	4.0E-04	9.7E-08
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.8E-11	NA	NA
Aroclor-1260	1.2E-11	NA	NA
Arsenic	2.1E-11	3.0E-04	7.0E-08
Barium	2.6E-11	7.0E-02	3.7E-10
Beryllium	1.2E-12	5.0E-03	2.3E-10
Boron	2.1E-10	9.0E-02	2.3E-09
Cadmium	4.5E-12	1.0E-03	4.5E-09
Carbazole	NA	NA	NA
Chromium	1.3E-10	5.0E-03	2.6E-08
Cobalt	3.6E-10	6.0E-02	6.0E-09
Copper	4.0E-10	NA	NA
Cyanide	2.5E-17	2.0E-02	1.3E-15
Endrin	3.4E-14	3.0E-04	1.1E-10
Lead	1.2E-11	NA	NA
Manganese	6.0E-10	1.4E-01	4.3E-09
Mercury	1.4E-10	3.0E-04	4.7E-07
Molybdenum	6.4E-11	5.0E-03	1.3E-08
Nickel	2.1E-10	2.0E-02	1.0E-08
Selenium	1.9E-11	5.0E-03	3.8E-09
Silver	3.8E-11	5.0E-03	7.7E-09
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	3.4E-11	8.0E-05	4.3E-07
Thorium	NA	NA	NA
Uranium	2.3E-10	3.0E-03	7.5E-08
Vanadium	1.0E-10	7.0E-03	1.5E-08
Zinc	1.7E-08	3.0E-01	5.6E-08
	HQ Summation =		1.3E-06

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	8.4E-14	3.4E-01	2.9E-14
Antimony	3.3E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.5E-12	7.7E+00	1.2E-11
Aroclor-1260	1.0E-12	7.7E+00	8.0E-12
Arsenic	1.8E-12	1.8E+00	3.2E-12
Barium	2.2E-12	NA	NA
Beryllium	9.9E-14	4.3E+00	4.3E-13
Boron	1.8E-11	NA	NA
Cadmium	3.9E-13	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	1.1E-11	NA	NA
Cobalt	3.1E-11	NA	NA
Copper	3.4E-11	NA	NA
Cyanide	2.2E-18	NA	NA
Endrin	2.9E-15	NA	NA
Lead	1.1E-12	NA	NA
Manganese	5.2E-11	NA	NA
Mercury	1.2E-11	NA	NA
Molybdenum	5.5E-12	NA	NA
Nickel	1.8E-11	NA	NA
Selenium	1.6E-12	NA	NA
Silver	3.3E-12	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	2.9E-12	NA	NA
Thorium	NA	NA	NA
Uranium	1.9E-11	NA	NA
Vanadium	8.8E-12	NA	NA
Zinc	1.4E-09	NA	NA
	ILCR Summation =		2.3E-11

Table I.IV–29
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Current Land Use Scenario
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.029 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Cs-137	1.0E-05	pCi/kg	Ru-106	0.0E+00	pCi/kg
Np-237	2.1E-05	pCi/kg	Sr-90	NA	pCi/kg
Pa-231	1.7E-05	pCi/kg	Tc-99	NA	pCi/kg
Pb-210	0.0E+00	pCi/kg	Th-228	1.4E-09	pCi/kg
Pu-238	1.6E-10	pCi/kg	Th-230	1.6E-08	pCi/kg
Pu-239	4.0E-11	pCi/kg	Th-232	5.9E-09	pCi/kg
Pu-240	1.4E-10	pCi/kg	U-234	9.3E-02	pCi/kg
Ra-226	5.1E-08	pCi/kg	U-235	2.5E-03	pCi/kg
Ra-228	8.9E-08	pCi/kg	U-236	1.0E-03	pCi/kg
Rn-222	0.0E+00	pCi/kg	U-238	5.5E-02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	6.2E-04	2.8E-11	1.7E-14
Np-237	1.3E-03	2.2E-10	2.8E-13
Pa-231	1.0E-03	9.2E-11	9.3E-14
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	9.6E-09	2.2E-10	2.1E-18
Pu-239	2.4E-09	2.3E-10	5.6E-19
Pu-240	8.8E-09	2.3E-10	2.0E-18
Ra-226	3.1E-06	1.2E-10	3.7E-16
Ra-228	5.4E-06	1.0E-10	5.4E-16
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	0.0E+00	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	NA	1.3E-12	NA
Th-228	8.5E-08	5.5E-11	4.7E-18
Th-230	9.8E-07	1.3E-11	1.3E-17
Th-232	3.6E-07	1.2E-11	4.3E-18
U-234	5.6E+00	1.6E-11	9.0E-11
U-235	1.5E-01	1.6E-11	2.4E-12
U-236	6.2E-02	1.5E-11	9.2E-13
U-238	3.4E+00	2.8E-11	9.4E-11
		ILCR Summation =	1.9E-10

Table I.IV-30
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
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	0.68 l/day
FI	Fraction ingested from contaminated source	1 (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 x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	0.0E+00	mg/l
4,4-DDE	1.0E-10	mg/l
Antimony	2.4E-09	mg/l
Aroclor-1221	NA	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	3.0E-09	mg/l
Aroclor-1260	2.1E-09	mg/l
Arsenic	3.4E-10	mg/l
Barium	3.3E-08	mg/l
Beryllium	5.6E-13	mg/l
Boron	2.1E-07	mg/l
Cadmium	4.4E-09	mg/l
Carbazole	0.0E+00	mg/l
Chromium	1.9E-08	mg/l
Cobalt	1.9E-08	mg/l
Copper	3.3E-08	mg/l

Compound	Concentration	Units
Cyanide	4.4E-15	mg/l
Endrin	2.7E-12	mg/l
Lead	5.5E-09	mg/l
Manganese	2.8E-07	mg/l
Mercury	1.4E-10	mg/l
Molybdenum	8.6E-09	mg/l
Nickel	1.9E-08	mg/l
Selenium	2.7E-09	mg/l
Silver	1.4E-07	mg/l
Tetrachlordibenzo-p-dioxin	0.0E+00	mg/l
Thallium	9.2E-10	mg/l
Thorium	0.0E+00	mg/l
Uranium	3.7E-07	mg/l
Vanadium	4.4E-10	mg/l
Zinc	9.0E-07	mg/l

References

Table I.IV-30 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.5E-12	NA	NA
Antimony	1.0E-10	4.0E-04	2.6E-07
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.3E-10	NA	NA
Aroclor-1260	8.9E-11	NA	NA
Arsenic	1.5E-11	3.0E-04	4.9E-08
Barium	1.4E-09	7.0E-02	2.0E-08
Beryllium	2.4E-14	5.0E-03	4.9E-12
Boron	9.3E-09	9.0E-02	1.0E-07
Cadmium	1.9E-10	1.0E-03	1.9E-07
Carbazole	NA	NA	NA
Chromium	8.3E-10	5.0E-03	1.7E-07
Cobalt	8.5E-10	6.0E-02	1.4E-08
Copper	1.4E-09	NA	NA
Cyanide	1.9E-16	2.0E-02	9.5E-15
Endrin	1.2E-13	3.0E-04	3.9E-10
Lead	2.4E-10	NA	NA
Manganese	1.2E-08	1.4E-01	8.8E-08
Mercury	5.9E-12	3.0E-04	2.0E-08
Molybdenum	3.7E-10	5.0E-03	7.5E-08
Nickel	8.2E-10	2.0E-02	4.1E-08
Selenium	1.2E-10	5.0E-03	2.4E-08
Silver	6.0E-09	5.0E-03	1.2E-06
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	4.0E-11	8.0E-05	5.0E-07
Thorium	NA	NA	NA
Uranium	1.6E-08	3.0E-03	5.3E-06
Vanadium	1.9E-11	7.0E-03	2.7E-09
Zinc	3.9E-08	3.0E-01	1.3E-07
	HQ Summation =		8.2E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	3.8E-13	3.4E-01	1.3E-13
Antimony	9.0E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.1E-11	7.7E+00	8.7E-11
Aroclor-1260	7.7E-12	7.7E+00	5.9E-11
Arsenic	1.3E-12	1.8E+00	2.3E-12
Barium	1.2E-10	NA	NA
Beryllium	2.1E-15	4.3E+00	9.0E-15
Boron	7.9E-10	NA	NA
Cadmium	1.7E-11	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	7.1E-11	NA	NA
Cobalt	7.3E-11	NA	NA
Copper	1.2E-10	NA	NA
Cyanide	1.6E-17	NA	NA
Endrin	1.0E-14	NA	NA
Lead	2.1E-11	NA	NA
Manganese	1.1E-09	NA	NA
Mercury	5.1E-13	NA	NA
Molybdenum	3.2E-11	NA	NA
Nickel	7.0E-11	NA	NA
Selenium	1.0E-11	NA	NA
Silver	5.1E-10	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	3.4E-12	NA	NA
Thorium	NA	NA	NA
Uranium	1.4E-09	NA	NA
Vanadium	1.6E-12	NA	NA
Zinc	3.4E-09	NA	NA
	ILCR Summation =		1.5E-10

Table I.IV–31
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Current Land Use Scenario
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.68 l/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Cs-137	3.55E-06	pCi/l	Ru-106	7.81E-32	pCi/l
Np-237	2.31E-06	pCi/l	Sr-90	1.78E-27	pCi/l
Pa-231	1.0E-07	pCi/l	Tc-99	3.47E-19	pCi/l
Pb-210	0.0E+00	pCi/l	Th-228	1.78E-09	pCi/l
Pu-238	3.2E-11	pCi/l	Th-230	1.35E-08	pCi/l
Pu-239	7.9E-12	pCi/l	Th-232	4.90E-09	pCi/l
Pu-240	2.9E-11	pCi/l	U-234	3.34E-01	pCi/l
Ra-226	1.4E-07	pCi/l	U-235	8.86E-03	pCi/l
Ra-228	2.5E-07	pCi/l	U-236	3.64E-03	pCi/l
Rn-222	0.0E+00	pCi/l	U-238	1.99E-01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	5.1E-03	2.8E-11	1.4E-13
Np-237	3.3E-03	2.2E-10	7.2E-13
Pa-231	1.5E-04	9.2E-11	1.4E-14
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	4.5E-08	2.2E-10	9.9E-18
Pu-239	1.1E-08	2.3E-10	2.6E-18
Pu-240	4.1E-08	2.3E-10	9.5E-18
Ra-226	2.0E-04	1.2E-10	2.4E-14
Ra-228	3.5E-04	1.0E-10	3.5E-14
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	1.1E-28	9.5E-12	1.1E-39
Sr-90	2.5E-24	3.6E-11	9.1E-35
Tc-99	5.0E-16	1.3E-12	6.4E-28
Th-228	2.5E-06	5.5E-11	1.4E-16
Th-230	1.9E-05	1.3E-11	2.5E-16
Th-232	7.0E-06	1.2E-11	8.4E-17
U-234	4.8E+02	1.6E-11	7.6E-09
U-235	1.3E+01	1.6E-11	2.0E-10
U-236	5.2E+00	1.5E-11	7.8E-11
U-238	2.8E+02	2.8E-11	8.0E-09
		ILCR Summation =	1.6E-08

Table I.IV-32
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
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	0.106 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 x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	5.3E-10	mg/kg
4,4-DDE	1.4E-10	mg/kg
Antimony	7.4E-08	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	4.7E-09	mg/kg
Aroclor-1260	2.6E-09	mg/kg
Arsenic	7.3E-08	mg/kg
Barium	1.2E-06	mg/kg
Beryllium	8.1E-09	mg/kg
Boron	1.6E-06	mg/kg
Cadmium	5.2E-08	mg/kg
Carbazole	1.0E-09	mg/kg
Chromium	1.7E-07	mg/kg
Cobalt	1.3E-07	mg/kg
Copper	2.8E-07	mg/kg

Compound	Concentration	Units
Cyanide	3.1E-09	mg/kg
Endrin	2.0E-11	mg/kg
Lead	2.9E-07	mg/kg
Manganese	1.0E-05	mg/kg
Mercury	3.8E-09	mg/kg
Molybdenum	8.1E-08	mg/kg
Nickel	2.4E-07	mg/kg
Selenium	8.9E-09	mg/kg
Silver	8.8E-08	mg/kg
Tetrachlordibenzo-p-dioxin	2.8E-15	mg/kg
Thallium	6.0E-09	mg/kg
Thorium	3.1E-07	mg/kg
Uranium	7.9E-06	mg/kg
Vanadium	2.9E-07	mg/kg
Zinc	9.8E-07	mg/kg

References

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Table I.IV-32 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Current Land Use Scenario
Via Ingestion of Vegetables and Fruits

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	1.8E-12	NA	NA
4,4-DDE	4.8E-13	NA	NA
Antimony	2.5E-10	4.0E-04	6.3E-07
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.6E-11	NA	NA
Aroclor-1260	8.9E-12	NA	NA
Arsenic	2.5E-10	3.0E-04	8.2E-07
Barium	4.0E-09	7.0E-02	5.7E-08
Beryllium	2.7E-11	5.0E-03	5.5E-09
Boron	5.5E-09	9.0E-02	6.1E-08
Cadmium	1.8E-10	1.0E-03	1.8E-07
Carbazole	3.4E-12	NA	NA
Chromium	5.6E-10	5.0E-03	1.1E-07
Cobalt	4.3E-10	6.0E-02	7.1E-09
Copper	9.4E-10	NA	NA
Cyanide	1.1E-11	2.0E-02	5.3E-10
Endrin	6.8E-14	3.0E-04	2.3E-10
Lead	9.7E-10	NA	NA
Manganese	3.5E-08	1.4E-01	2.5E-07
Mercury	1.3E-11	3.0E-04	4.3E-08
Molybdenum	2.7E-10	5.0E-03	5.5E-08
Nickel	8.3E-10	2.0E-02	4.1E-08
Selenium	3.0E-11	5.0E-03	6.0E-09
Silver	3.0E-10	5.0E-03	6.0E-08
Tetrachlordibenzo-p-dioxin	9.5E-18	NA	NA
Thallium	2.0E-11	8.0E-05	2.5E-07
Thorium	1.1E-09	NA	NA
Uranium	2.7E-08	3.0E-03	9.0E-06
Vanadium	9.7E-10	7.0E-03	1.4E-07
Zinc	3.3E-09	3.0E-01	1.1E-08
	HQ Summation =		1.2E-05

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	1.5E-13	NA	NA
4,4-DDE	4.1E-14	3.4E-01	1.4E-14
Antimony	2.2E-11	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.4E-12	7.7E+00	1.0E-11
Aroclor-1260	7.6E-13	7.7E+00	5.9E-12
Arsenic	2.1E-11	1.8E+00	3.8E-11
Barium	3.4E-10	NA	NA
Beryllium	2.4E-12	4.3E+00	1.0E-11
Boron	4.7E-10	NA	NA
Cadmium	1.5E-11	NA	NA
Carbazole	2.9E-13	2.0E-02	5.8E-15
Chromium	4.8E-11	NA	NA
Cobalt	3.7E-11	NA	NA
Copper	8.1E-11	NA	NA
Cyanide	9.0E-13	NA	NA
Endrin	5.8E-15	NA	NA
Lead	8.3E-11	NA	NA
Manganese	3.0E-09	NA	NA
Mercury	1.1E-12	NA	NA
Molybdenum	2.3E-11	NA	NA
Nickel	7.1E-11	NA	NA
Selenium	2.6E-12	NA	NA
Silver	2.6E-11	NA	NA
Tetrachlordibenzo-p-dioxin	8.1E-19	1.5E+05	1.2E-13
Thallium	1.7E-12	NA	NA
Thorium	9.1E-11	NA	NA
Uranium	2.3E-09	NA	NA
Vanadium	8.3E-11	NA	NA
Zinc	2.8E-10	NA	NA
	ILCR Summation =		6.5E-11

Table I.IV–33
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Current Land Use Scenario
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.106 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	

Cs-137	6.51E-06	pCi/kg	Ru-106	4.38E-17	pCi/kg
Np-237	2.65E-06	pCi/kg	Sr-90	4.09E-16	pCi/kg
Pa-231	2.7E-06	pCi/kg	Tc-99	7.50E-08	pCi/kg
Pb-210	1.1E-05	pCi/kg	Th-228	4.75E-06	pCi/kg
Pu-238	4.1E-06	pCi/kg	Th-230	3.51E-05	pCi/kg
Pu-239	1.0E-06	pCi/kg	Th-232	1.28E-05	pCi/kg
Pu-240	3.8E-06	pCi/kg	U-234	4.54E+01	pCi/kg
Ra-226	4.2E-06	pCi/kg	U-235	1.20E+00	pCi/kg
Ra-228	7.3E-06	pCi/kg	U-236	4.94E-01	pCi/kg
Rn-222	3.6E-01	pCi/kg	U-238	2.71E+01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	7.3E-04	2.8E-11	2.0E-14
Np-237	3.0E-04	2.2E-10	6.5E-14
Pa-231	3.0E-04	9.2E-11	2.8E-14
Pb-210	1.2E-03	6.6E-10	8.2E-13
Pu-238	4.6E-04	2.2E-10	1.0E-13
Pu-239	1.1E-04	2.3E-10	2.6E-14
Pu-240	4.2E-04	2.3E-10	9.6E-14
Ra-226	4.6E-04	1.2E-10	5.6E-14
Ra-228	8.1E-04	1.0E-10	8.1E-14
Rn-222	4.0E+01	1.7E-12	6.8E-11
Ru-106	4.9E-15	9.5E-12	4.6E-26
Sr-90	4.6E-14	3.6E-11	1.6E-24
Tc-99	8.3E-06	1.3E-12	1.1E-17
Th-228	5.3E-04	5.5E-11	2.9E-14
Th-230	3.9E-03	1.3E-11	5.1E-14
Th-232	1.4E-03	1.2E-11	1.7E-14
U-234	5.0E+03	1.6E-11	8.1E-08
U-235	1.3E+02	1.6E-11	2.1E-09
U-236	5.5E+01	1.5E-11	8.3E-10
U-238	3.0E+03	2.8E-11	8.4E-08
		ILCR Summation =	1.7E-07

FEMP-OU1&2CRARE-3-DRAFT
April 29, 1994

INTAKE AND RISK CALCULATIONS:
FUTURE LAND USE WITH FEDERAL OWNERSHIP SCENARIO

FER/OU12CRARE.ATT/SSO.C-3/04-29-94

Table I.IV-34
Summary of Intake Quantitation (chemicals)
Expanded Trespasser: Future Land Use With Federal Ownership
Via Inhalation of Particulates

Intake Equation $= \frac{CS \times EFa \times EDa \times IR \times ETa}{BWa \times ATa} + \frac{CS \times EFc \times EDc \times IR \times ETc}{BWc \times ATc}$

IR	Inhalation rate of gases	0.83 m^3/hour
ETa	Exposure time (adult)	1 hour/day
ETc	Exposure time (child)	2 hour/day
EFa	Exposure frequency (adult)	40 days/year
EFc	Exposure frequency (child)	110 days/year
EDa	Exposure duration (adult)	32 Year
EDc	Exposure duration (child)	12 Year
BWa	Body weight (adult)	70 kg
BWc	Body weight (child)	43 kg
AT	Average time for carcinogens	25550 days
ATa	Average time for non-carcinogens (adult)	11680 days
ATc	Average time for non-carcinogens (child)	4380 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3
4,4-DDE	1.0E-09	mg/m^3
Antimony	5.5E-07	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3
Arsenic	5.3E-07	mg/m^3
Barium	8.7E-06	mg/m^3
Beryllium	6.0E-08	mg/m^3
Boron	1.1E-05	mg/m^3
Cadmium	3.7E-07	mg/m^3
Carbazole	7.3E-09	mg/m^3
Chromium	1.2E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3
Copper	2.0E-06	mg/m^3

Compound	Concentration	Units
Cyanide	2.3E-08	mg/m^3
Endrin	1.5E-10	mg/m^3
Lead	2.1E-06	mg/m^3
Manganese	7.7E-05	mg/m^3
Mercury	2.8E-08	mg/m^3
Molybdenum	5.4E-07	mg/m^3
Nickel	1.8E-06	mg/m^3
Selenium	6.5E-08	mg/m^3
Silver	6.5E-07	mg/m^3
Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Thallium	4.4E-08	mg/m^3
Thorium	2.3E-06	mg/m^3
Uranium	5.8E-05	mg/m^3
Vanadium	2.1E-06	mg/m^3
Zinc	6.3E-06	mg/m^3

References

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Table I.IV-34 (continued)
Summary of Risk Characterization (chemicals)
Expanded Trespasser: Future Land Use With Federal Ownership
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	5.1E-11	NA	NA
4,4-DDE	1.3E-11	NA	NA
Antimony	7.1E-09	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	4.4E-10	NA	NA
Aroclor-1260	2.5E-10	NA	NA
Arsenic	6.9E-09	NA	NA
Barium	1.1E-07	1.0E-04	1.1E-03
Beryllium	7.7E-10	NA	NA
Boron	1.4E-07	5.7E-03	2.5E-05
Cadmium	4.8E-09	NA	NA
Carbazole	9.5E-11	NA	NA
Chromium	1.6E-08	NA	NA
Cobalt	1.2E-08	3.0E-07	4.0E-02
Copper	2.6E-08	NA	NA
Cyanide	3.0E-10	NA	NA
Endrin	1.9E-12	NA	NA
Lead	2.7E-08	NA	NA
Manganese	9.9E-07	1.1E-04	9.0E-03
Mercury	3.6E-10	8.6E-05	4.2E-06
Molybdenum	7.0E-09	NA	NA
Nickel	2.3E-08	NA	NA
Selenium	8.5E-10	NA	NA
Silver	8.3E-09	NA	NA
Tetrachlordibenzo-p-dioxin	2.7E-16	NA	NA
Thallium	5.7E-10	NA	NA
Thorium	3.0E-08	NA	NA
Uranium	7.6E-07	NA	NA
Vanadium	2.7E-08	NA	NA
Zinc	8.1E-08	NA	NA
	HQ Summation =		5.0E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	1.0E-11	NA	NA
4,4-DDE	2.7E-12	NA	NA
Antimony	1.4E-09	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	8.9E-11	NA	NA
Aroclor-1260	5.0E-11	NA	NA
Arsenic	1.4E-09	1.5E+01	2.1E-08
Barium	2.2E-08	NA	NA
Beryllium	1.5E-10	8.4E+00	1.3E-09
Boron	2.9E-08	NA	NA
Cadmium	9.7E-10	6.1E+00	5.9E-09
Carbazole	1.9E-11	NA	NA
Chromium	3.2E-09	4.1E+01	1.3E-07
Cobalt	2.4E-09	NA	NA
Copper	5.3E-09	NA	NA
Cyanide	5.9E-11	NA	NA
Endrin	3.8E-13	NA	NA
Lead	5.4E-09	NA	NA
Manganese	2.0E-07	NA	NA
Mercury	7.2E-11	NA	NA
Molybdenum	1.4E-09	NA	NA
Nickel	4.6E-09	8.4E-01	3.9E-09
Selenium	1.7E-10	NA	NA
Silver	1.7E-09	NA	NA
Tetrachlordibenzo-p-dioxin	5.3E-17	1.5E+05	8.0E-12
Thallium	1.1E-10	NA	NA
Thorium	6.0E-09	NA	NA
Uranium	1.5E-07	NA	NA
Vanadium	5.5E-09	NA	NA
Zinc	1.6E-08	NA	NA
	ILCR Summation =		1.6E-07

Table I.IV-35
Summary of Intake and Risk Quantitation (Radionuclides)
Expanded Trespasser: Future Land Use With Federal Ownership
Via Inhalation of Gases and Particulates

Intake Equation = CA X EFa X EDa X IR X ETa + CA X EFc EDc X IR X ETc

IR	Inhalation rate of gases	0.83	m^3/hour
EFa	Exposure frequency (adult)	40	days/year
EFc	Exposure frequency (child)	110	days/year
EDa	Exposure duration	32	Year
EDc	Exposure duration	12	Year
ETa	Exposure time (adult)	1	hour/day
ETc	Exposure time (child)	2	hour/day
CA	Concentration of radionuclides in air		(see table below)

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.6E-01	1.9E-11	2.9E-12
Np-237	6.3E-02	2.9E-08	1.8E-09
Pa-231	6.5E-02	3.6E-08	2.3E-09
Pb-210	2.7E-01	4.0E-09	1.1E-09
Pu-238	9.8E-02	3.9E-08	3.8E-09
Pu-239	2.5E-02	3.8E-08	9.4E-10
Pu-240	9.0E-02	3.8E-08	3.4E-09
Ra-226	1.0E-01	3.0E-09	3.1E-10
Ra-228	1.8E-01	6.9E-10	1.2E-10
Rn-222	8.7E+03	7.7E-12	6.7E-08
Ru-106	2.7E-02	4.4E-10	1.2E-11
Sr-90	2.6E-01	6.2E-11	1.6E-11
Tc-99	1.3E+00	8.3E-12	1.0E-11
Th-228	1.2E-01	7.8E-08	9.1E-09
Th-230	8.4E-01	2.9E-08	2.4E-08
Th-232	3.1E-01	2.8E-08	8.6E-09
U-234	7.8E+00	2.6E-08	2.0E-07
U-235	3.2E-01	2.5E-08	7.9E-09
U-236	1.9E+00	2.5E-08	4.7E-08
U-238	3.9E+00	5.2E-11	2.0E-10
		ILCR Summation =	3.8E-07

Table I.IV-36
Summary of Intake Quantitation (chemicals)
Expanded Trespasser: Future Land Use With Federal Ownership
Via Incidental Ingestion of Soil/Sediment

Intake Equation

$$= \frac{CS \times EFa \times EDa \times CF \times IRa}{BWa \times ATa} + \frac{CS \times EFc \times EDc \times CF \times IRc}{BWc \times ATc}$$

IRa	Ingestion rate of soil (adult)	12.5	mg/day
IRc	Ingestion rate of soil (child)	12.5	mg/day
CF	Conversion factor	1.00E-06	kg/mg
EFa	Exposure frequency (adult)	40	days/year
EFc	Exposure frequency (child)	110	days/year
EDa	Exposure duration (adult)	32	Year
EDc	Exposure duration (child)	12	Year
BWa	Body weight (adult)	70	kg
BWc	Body weight (child)	43	kg
AT	Average time for carcinogens	25550	days
ATa	Average time for non-carcinogens (adult)	11680	days
ATc	Average time for non-carcinogens (child)	4380	days
CS	Concentration of chemicals in soil	(see table below)	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/kg
4,4-DDE	NA	mg/kg
Antimony	5.4E+00	mg/kg
Aroclor-1221	NA	mg/kg
Aroclor-1248	NA	mg/kg
Aroclor-1254	NA	mg/kg
Aroclor-1260	NA	mg/kg
Arsenic	5.1E+00	mg/kg
Barium	9.7E+01	mg/kg
Beryllium	7.6E-01	mg/kg
Boron	1.1E+02	mg/kg
Cadmium	3.5E+00	mg/kg
Carbazole	NA	mg/kg
Chromium	1.6E+01	mg/kg
Cobalt	1.2E+01	mg/kg
Copper	2.0E+01	mg/kg

Compound	Concentration	Units
Cyanide	2.5E-01	mg/kg
Endrin	NA	mg/kg
Lead	2.4E+01	mg/kg
Manganese	9.8E+02	mg/kg
Mercury	2.1E-01	mg/kg
Molybdenum	6.5E+00	mg/kg
Nickel	2.3E+01	mg/kg
Selenium	6.3E-01	mg/kg
Silver	6.0E+00	mg/kg
Tetrachlordibenzo-p-dioxin	3.5E-08	mg/kg
Thallium	5.6E-01	mg/kg
Thorium	NA	mg/kg
Uranium	NA	mg/kg
Vanadium	2.6E+01	mg/kg
Zinc	6.4E+01	mg/kg

References

Table I.IV-36 (continued)
Summary of Risk Characterization (chemicals)
Expanded Trespasser: Future Land Use With Federal Ownership
Via Incidental Ingestion of Soil/Sediment

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	5.7E-07	4.0E-04	1.4E-03
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	5.5E-07	3.0E-04	1.8E-03
Barium	1.0E-05	7.0E-02	1.5E-04
Beryllium	8.1E-08	5.0E-03	1.6E-05
Boron	1.2E-05	9.0E-02	1.3E-04
Cadmium	3.7E-07	1.0E-03	3.7E-04
Carbazole	NA	NA	NA
Chromium	1.8E-06	5.0E-03	3.5E-04
Cobalt	1.3E-06	6.0E-02	2.2E-05
Copper	2.2E-06	NA	NA
Cyanide	2.7E-08	2.0E-02	1.3E-06
Endrin	NA	3.0E-04	NA
Lead	2.5E-06	NA	NA
Manganese	1.0E-04	1.4E-01	7.5E-04
Mercury	2.3E-08	3.0E-04	7.6E-05
Molybdenum	7.0E-07	5.0E-03	1.4E-04
Nickel	2.4E-06	2.0E-02	1.2E-04
Selenium	6.8E-08	5.0E-03	1.4E-05
Silver	6.5E-07	5.0E-03	1.3E-04
Tetrachlordibenzo-p-dioxin	3.7E-15	NA	NA
Thallium	6.0E-08	8.0E-05	7.5E-04
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	NA
Vanadium	2.8E-06	7.0E-03	4.0E-04
Zinc	6.9E-06	3.0E-01	2.3E-05
	HQ Summation =		6.7E-03

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	1.3E-07	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	1.2E-07	1.8E+00	2.2E-07
Barium	2.3E-06	NA	NA
Beryllium	1.8E-08	4.3E+00	7.8E-08
Boron	2.7E-06	NA	NA
Cadmium	8.3E-08	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	3.9E-07	NA	NA
Cobalt	2.9E-07	NA	NA
Copper	4.8E-07	NA	NA
Cyanide	6.0E-09	NA	NA
Endrin	NA	NA	NA
Lead	5.6E-07	NA	NA
Manganese	2.3E-05	NA	NA
Mercury	5.1E-09	NA	NA
Molybdenum	1.6E-07	NA	NA
Nickel	5.4E-07	NA	NA
Selenium	1.5E-08	NA	NA
Silver	1.4E-07	NA	NA
Tetrachlordibenzo-p-dioxin	8.3E-16	1.5E+05	1.3E-10
Thallium	1.3E-08	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	6.2E-07	NA	NA
Zinc	1.5E-06	NA	NA
	ILCR Summation =		3.0E-07

Table I.IV-37
Summary of Intake and Risk Quantitation (Radionuclides)
Expanded Trespasser: Future Land Use With Federal Ownership
Via Incidental Ingestion of Soil/Sediment

Intake Equation = CS X EFa X EDa X FI X IRa + CS X EFc X EDc X FI X IRc

IRa	Ingestion rate of soil (adult)	12.5 mg/day
IRc	Ingestion rate of soil (child)	12.5 mg/day
EFa	Exposure frequency (adult)	40 days/year
EFc	Exposure frequency (child)	110 days/year
EDa	Exposure Duration	32 Year
EDc	Exposure Duration	12 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	(see table below)

Cs-137	5.8E-04	pCi/mg	Ru-106	1.3E-04	pCi/mg
Np-237	8.4E-05	pCi/mg	Sr-90	8.3E-04	pCi/mg
Pa-231	NA	pCi/mg	Tc-99	1.9E-03	pCi/mg
Pb-210	1.1E-03	pCi/mg	Th-228	4.0E-04	pCi/mg
Pu-238	9.1E-05	pCi/mg	Th-230	5.9E-05	pCi/mg
Pu-239	1.3E-05	pCi/mg	Th-232	6.0E-04	pCi/mg
Pu-240	4.6E-05	pCi/mg	U-234	2.1E-02	pCi/mg
Ra-226	4.0E-04	pCi/mg	U-235	9.3E-04	pCi/mg
Ra-228	7.0E-04	pCi/mg	U-236	6.9E-03	pCi/mg
Rn-222	NA	pCi/mg	U-238	1.4E-02	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.9E+01	2.8E-11	5.3E-10
Np-237	2.7E+00	2.2E-10	6.0E-10
Pa-231	NA	9.2E-11	NA
Pb-210	3.4E+01	6.6E-10	2.3E-08
Pu-238	2.9E+00	2.2E-10	6.5E-10
Pu-239	4.1E-01	2.3E-10	9.3E-11
Pu-240	1.5E+00	2.3E-10	3.4E-10
Ra-226	1.3E+01	1.2E-10	1.6E-09
Ra-228	2.3E+01	1.0E-10	2.3E-09
Rn-222	NA	1.7E-12	NA
Ru-106	4.3E+00	9.5E-12	4.1E-11
Sr-90	2.7E+01	3.6E-11	9.7E-10
Tc-99	6.1E+01	1.3E-12	7.9E-11
Th-228	1.3E+01	5.5E-11	7.2E-10
Th-230	1.9E+00	1.3E-11	2.5E-11
Th-232	1.9E+01	1.2E-11	2.3E-10
U-234	6.7E+02	1.6E-11	1.1E-08
U-235	3.0E+01	1.6E-11	4.9E-10
U-236	2.2E+02	1.5E-11	3.3E-09
U-238	4.5E+02	2.8E-11	1.3E-08
		ILCR Summation =	5.8E-08

Table I.IV–38
Summary of Intake and Risk Quantitation (Radionuclides)
Expanded Trespasser: Future Land Use With Federal Ownership
Via Incidental Ingestion while Wading

Intake Equation = CS X EFa X EDa X FI X IRsw + CS X EFc X EDc X FI X IRsw

IRsw	Ingestion rate of surface water	0.035	l/day
EFa	Exposure frequency (adult)	0	days/year
EFc	Exposure frequency (child)	52	days/year
EDa	Exposure duration (adult)	0	Year
EDc	Exposure duration (child)	12	Year
FI	Fractional intake for radionuclides	1	(Unitless)
Cs	Concentration of radionuclides in surface water		(see table below)

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	NA	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	8.8E+02	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	2.0E+01	pCi/l
Ra-226	NA	pCi/l	U-235	5.3E-01	pCi/l
Ra-228	NA	pCi/l	U-236	2.2E-01	pCi/l
Rn-222	NA	pCi/l	U-238	1.2E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	NA	2.2E-10	NA
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	1.9E+04	1.3E-12	2.5E-08
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	4.4E+02	1.6E-11	7.0E-09
U-235	1.2E+01	1.6E-11	1.9E-10
U-236	4.8E+00	1.5E-11	7.2E-11
U-238	2.6E+02	2.8E-11	7.4E-09
ILCR Summation		=	4.0E-08

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Table I.IV-39
Summary of Intake Quantitation (chemicals)
Expanded Trespasser: Future Land Use With Federal Ownership
Via Dermal Contact with Soil/Sediment

Intake Equation

$$= \frac{CS \times EFa \times EDa \times CF \times ABS \times AF \times SAa}{BWa \times ATa} + \frac{CS \times EFc \times EDc \times CF \times ABS \times AF \times SAc}{BWc \times ATc}$$

SA	Surface area of exposed skin (adult)	5750 cm^2/day
SA	Surface area of exposed skin (child)	4200 cm^2/day
AF	Soil to skin adherence factor	1 mg/cm^2
ABS	chemicals specific absorbtion factor (see table below)	csv
CF	Conversion factor	1E-06 kg/mg
EFa	Exposure frequency (adult)	40 days/year
EFc	Exposure frequency (child)	110 days/year
EDa	Exposure duration (adult)	32 Year
EDc	Exposure duration (child)	12 Year
BWa	Body weight (adult)	70 kg
BWc	Body weight (child)	43 kg
AT	Average time for carcinogens	25550 days
ATa	Average time for non-carcinogens (adult)	11680 days
ATc	Average time for non-carcinogens (child)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	ABS	Concentrati	Units
2-Methylnaphthalene	3.0E-01	NA	mg/kg
4,4-DDE	3.0E-01	NA	mg/kg
Antimony	1.0E-02	5.4E+00	mg/kg
Aroclor-1221	6.0E-02	NA	mg/kg
Aroclor-1248	6.0E-02	NA	mg/kg
Aroclor-1254	6.0E-02	NA	mg/kg
Aroclor-1260	6.0E-02	NA	mg/kg
Arsenic	1.0E-03	5.1E+00	mg/kg
Barium	1.0E-02	9.7E+01	mg/kg
Beryllium	1.0E-02	7.6E-01	mg/kg
Boron	1.0E-02	1.1E+02	mg/kg
Cadmium	1.0E-02	3.5E+00	mg/kg
Carbazole	3.0E-01	NA	mg/kg
Chromium	1.0E-02	1.6E+01	mg/kg
Cobalt	1.0E-02	1.2E+01	mg/kg
Copper	1.0E-03	2.0E+01	mg/kg

Compound	ABS	Concentrati	Units
Cyanide	1.0E-02	2.5E-01	mg/kg
Endrin	3.0E-01	NA	mg/kg
Lead	1.0E-02	2.4E+01	mg/kg
Manganese	1.0E-02	9.8E+02	mg/kg
Mercury	5.0E-02	2.1E-01	mg/kg
Molybdenum	1.0E-02	6.5E+00	mg/kg
Nickel	5.0E-04	2.3E+01	mg/kg
Selenium	1.0E-02	6.3E-01	mg/kg
Silver	1.0E-02	6.0E+00	mg/kg
Tetrachlordibenzo-p-dioxin	3.0E-02	3.5E-08	mg/kg
Thallium	1.0E-02	5.6E-01	mg/kg
Thorium	1.0E-02	NA	mg/kg
Uranium	1.0E-02	NA	mg/kg
Vanadium	1.0E-03	2.6E+01	mg/kg
Zinc	1.0E-02	6.4E+01	mg/kg

References

Table I.IV-39 (continued)
Summary of Risk Characterization (chemicals)
Expanded Trespasser: Future Land Use With Federal Ownership
Via Dermal Contact with Soil/Sediment

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	2.1E-06	6.0E-05	3.4E-02
Aroclor-1221	NA	5.3E-05	NA
Aroclor-1248	NA	5.3E-05	NA
Aroclor-1254	NA	5.3E-05	NA
Aroclor-1260	NA	5.3E-05	NA
Arsenic	2.0E-07	2.9E-04	6.9E-04
Barium	3.7E-05	6.4E-02	5.9E-04
Beryllium	2.9E-07	5.0E-05	5.8E-03
Boron	4.3E-05	4.5E-03	9.6E-03
Cadmium	1.3E-06	5.0E-05	2.7E-02
Carbazole	NA	NA	NA
Chromium	6.3E-06	2.3E-03	2.8E-03
Cobalt	4.7E-06	2.7E-02	1.7E-04
Copper	7.8E-07	2.2E-02	3.5E-05
Cyanide	9.6E-08	NA	NA
Endrin	NA	2.7E-04	NA
Lead	9.0E-06	NA	NA
Manganese	3.8E-04	4.2E-03	8.9E-02
Mercury	4.1E-07	4.5E-05	9.1E-03
Molybdenum	2.5E-06	1.9E-03	1.3E-03
Nickel	4.3E-07	2.0E-03	2.2E-04
Selenium	2.4E-07	4.0E-03	6.1E-05
Silver	2.3E-06	NA	NA
Tetrachlordibenzo-p-dioxin	4.0E-14	NA	NA
Thallium	2.1E-07	6.0E-05	3.6E-03
Thorium	NA	NA	NA
Uranium	NA	1.5E-04	NA
Vanadium	1.0E-06	3.5E-04	2.9E-03
Zinc	2.5E-05	7.5E-02	3.3E-04
	HQ Summation =		1.9E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.8E-01	NA
Antimony	4.9E-07	NA	NA
Aroclor-1221	NA	1.0E+01	NA
Aroclor-1248	NA	1.0E+01	NA
Aroclor-1254	NA	1.0E+01	NA
Aroclor-1260	NA	1.0E+01	NA
Arsenic	4.7E-08	1.9E+00	8.9E-08
Barium	8.9E-06	NA	NA
Beryllium	6.9E-08	4.3E+02	3.0E-05
Boron	1.0E-05	NA	NA
Cadmium	3.2E-07	NA	NA
Carbazole	NA	2.2E-02	NA
Chromium	1.5E-06	NA	NA
Cobalt	1.1E-06	NA	NA
Copper	1.9E-07	NA	NA
Cyanide	2.3E-08	NA	NA
Endrin	NA	NA	NA
Lead	2.2E-06	NA	NA
Manganese	8.9E-05	NA	NA
Mercury	9.8E-08	NA	NA
Molybdenum	5.9E-07	NA	NA
Nickel	1.0E-07	NA	NA
Selenium	5.8E-08	NA	NA
Silver	5.5E-07	NA	NA
Tetrachlordibenzo-p-dioxin	9.6E-15	3.0E+05	2.9E-09
Thallium	5.1E-08	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	2.4E-07	NA	NA
Zinc	5.9E-06	NA	NA
	ILCR Summation =		3.0E-05

Table I.IV–40
Summary of Risk Quantitation (Radionuclides)
Expanded Trespasser: Future Land Use With Federal Ownership
Via External Radiation

Exposure Equation = $[CR \times EFa \times EDa \times ET_{oa} \times (1-SH_o)]+[CR \times EFc \times EDc \times ET_{oc} \times (1-SH_o)]$

EFa	Fraction of year spent exposured (adult)	0.05 (unitless)
EFc	Fraction of year spent exposured (child)	0.16 (unitless)
EDa	Exposure duration (adult)	32 Year
EDc	Exposure duration (child)	12 Year
ET_{oa}	Fraction of day spent outdoors (adult)	0.04 (unitless)
ET_{oc}	Fraction of day spent outdoors (child)	0.08 (unitless)
SH_o	Shield factor outdoors	0 (unitless)
CR	Radionuclide specific concentrations	(see table below)

Cs-137	5.8E-01	pCi/g	Ru-106	1.3E-01	pCi/g
Np-237	8.4E-02	pCi/g	Sr-90	8.3E-01	pCi/g
Pa-231	NA	pCi/g	Tc-99	1.9E+00	pCi/g
Pb-210	1.1E+00	pCi/g	Th-228	4.0E-01	pCi/g
Pu-238	9.1E-02	pCi/g	Th-230	5.9E-02	pCi/g
Pu-239	1.3E-02	pCi/g	Th-232	NA	pCi/g
Pu-240	4.6E-02	pCi/g	U-234	2.1E+01	pCi/g
Ra-226	4.0E-01	pCi/g	U-235	9.3E-01	pCi/g
Ra-228	7.0E-01	pCi/g	U-236	6.9E+00	pCi/g
Rn-222	NA	pCi/g	U-238	1.4E+01	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs-137	1.3E-01	2.0E-06	2.5E-07
Np-237	1.8E-02	4.3E-07	7.8E-09
Pa-231	NA	2.6E-08	NA
Pb-210	2.3E-01	1.6E-10	3.7E-11
Pu-238	2.0E-02	2.8E-11	5.5E-13
Pu-239	2.7E-03	1.7E-11	4.6E-14
Pu-240	9.9E-03	2.7E-11	2.7E-13
Ra-226	8.7E-02	6.0E-06	5.2E-07
Ra-228	1.5E-01	2.9E-06	4.4E-07
Rn-222	NA	5.9E-06	NA
Ru-106	2.9E-02	NA	NA
Sr-90	1.8E-01	NA	NA
Tc-99	4.1E-01	6.0E-13	2.4E-13
Th-228	8.7E-02	5.6E-06	4.9E-07
Th-230	1.3E-02	5.4E-11	7.0E-13
Th-232	NA	2.6E-11	NA
U-234	4.5E+00	3.0E-11	1.3E-10
U-235	2.0E-01	2.4E-07	4.9E-08
U-236	1.5E+00	2.4E-11	3.6E-11
U-238	3.0E+00	3.6E-08	1.1E-07
		ILCR Summation =	1.9E-06

Table I.IV-41
Summary of Intake Quantitation (chemicals)
Trespassing Child Future Land Use With Federal Ownership (age 7-18)
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR \times ET}{BW \times AT}$

IR	Inhalation rate of gases (RAGS, 1989)	0.83 m^3/hour
ET	Exposure time	4 hours/day
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non-carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3
4,4-DDE	1.0E-09	mg/m^3
Antimony	5.5E-07	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3
Arsenic	5.3E-07	mg/m^3
Barium	8.7E-06	mg/m^3
Beryllium	6.0E-08	mg/m^3
Boron	1.1E-05	mg/m^3
Cadmium	3.7E-07	mg/m^3
Carbazole	7.3E-09	mg/m^3
Chromium	1.2E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3
Copper	2.0E-06	mg/m^3

Compound	Concentration	Units
Cyanide	2.3E-08	mg/m^3
Endrin	1.5E-10	mg/m^3
Lead	2.1E-06	mg/m^3
Manganese	7.7E-05	mg/m^3
Mercury	2.8E-08	mg/m^3
Molybdenum	5.4E-07	mg/m^3
Nickel	1.8E-06	mg/m^3
Selenium	6.5E-08	mg/m^3
Silver	6.5E-07	mg/m^3
Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Thallium	4.4E-08	mg/m^3
Thorium	2.3E-06	mg/m^3
Uranium	5.8E-05	mg/m^3
Vanadium	2.1E-06	mg/m^3
Zinc	6.3E-06	mg/m^3

References

Table I.IV-41 (continued)
Summary of Risk Characterization (chemicals)
Trespassing Child Future Land Use With Federal Ownership (age 7-18)
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	4.3E-11	NA	NA
4,4-DDE	1.1E-11	NA	NA
Antimony	6.0E-09	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	3.8E-10	NA	NA
Aroclor-1260	2.1E-10	NA	NA
Arsenic	5.9E-09	NA	NA
Barium	9.6E-08	1.0E-04	9.6E-04
Beryllium	6.6E-10	NA	NA
Boron	1.2E-07	5.7E-03	2.1E-05
Cadmium	4.1E-09	NA	NA
Carbazole	8.1E-11	NA	NA
Chromium	1.3E-08	NA	NA
Cobalt	1.0E-08	3.0E-07	3.4E-02
Copper	2.2E-08	NA	NA
Cyanide	2.5E-10	NA	NA
Endrin	1.6E-12	NA	NA
Lead	2.3E-08	NA	NA
Manganese	8.4E-07	1.1E-04	7.7E-03
Mercury	3.0E-10	8.6E-05	3.5E-06
Molybdenum	5.9E-09	NA	NA
Nickel	2.0E-08	NA	NA
Selenium	7.2E-10	NA	NA
Silver	7.1E-09	NA	NA
Tetrachlordibenzo-p-dioxin	2.3E-16	NA	NA
Thallium	4.8E-10	NA	NA
Thorium	2.5E-08	NA	NA
Uranium	6.4E-07	NA	NA
Vanadium	2.3E-08	NA	NA
Zinc	6.9E-08	NA	NA
	HQ Summation =		4.3E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	7.4E-12	NA	NA
4,4-DDE	1.9E-12	NA	NA
Antimony	1.0E-09	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	6.4E-11	NA	NA
Aroclor-1260	3.6E-11	NA	NA
Arsenic	1.0E-09	1.5E+01	1.5E-08
Barium	1.6E-08	NA	NA
Beryllium	1.1E-10	8.4E+00	9.4E-10
Boron	2.1E-08	NA	NA
Cadmium	7.1E-10	6.1E+00	4.3E-09
Carbazole	1.4E-11	NA	NA
Chromium	2.3E-09	4.1E+01	9.4E-08
Cobalt	1.8E-09	NA	NA
Copper	3.8E-09	NA	NA
Cyanide	4.3E-11	NA	NA
Endrin	2.8E-13	NA	NA
Lead	4.0E-09	NA	NA
Manganese	1.4E-07	NA	NA
Mercury	5.2E-11	NA	NA
Molybdenum	1.0E-09	NA	NA
Nickel	3.4E-09	8.4E-01	2.8E-09
Selenium	1.2E-10	NA	NA
Silver	1.2E-09	NA	NA
Tetrachlordibenzo-p-dioxin	3.9E-17	1.5E+05	5.8E-12
Thallium	8.3E-11	NA	NA
Thorium	4.3E-09	NA	NA
Uranium	1.1E-07	NA	NA
Vanadium	4.0E-09	NA	NA
Zinc	1.2E-08	NA	NA
	ILCR Summation =		1.2E-07

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Table I.IV–42
Summary of Intake and Risk Quantitation (Radionuclides)
Trespassing Child Future Land Use With Federal Ownership (age 7–18)
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X ET X IR

IR	Inhalation rate of gases (RAGS, 1989)	0.83 m^3/hour
EF	Exposure frequency	52 days/year
EDn	Exposure duration	12 Year
ET	Exposure time	4 hours/day
Ca	Concentration of radionuclides in air	

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	9.9E-02	1.9E-11	1.9E-12
Np-237	4.0E-02	2.9E-08	1.2E-09
Pa-231	4.1E-02	3.6E-08	1.5E-09
Pb-210	1.7E-01	4.0E-09	6.9E-10
Pu-238	6.3E-02	3.9E-08	2.4E-09
Pu-239	1.6E-02	3.8E-08	6.0E-10
Pu-240	5.7E-02	3.8E-08	2.2E-09
Ra-226	6.5E-02	3.0E-09	2.0E-10
Ra-228	1.1E-01	6.9E-10	7.8E-11
Rn-222	5.5E+03	7.7E-12	4.2E-08
Ru-106	1.7E-02	4.4E-10	7.6E-12
Sr-90	1.7E-01	6.2E-11	1.0E-11
Tc-99	8.0E-01	8.3E-12	6.7E-12
Th-228	7.4E-02	7.8E-08	5.8E-09
Th-230	5.3E-01	2.9E-08	1.6E-08
Th-232	1.9E-01	2.8E-08	5.4E-09
U-234	5.0E+00	2.6E-08	1.3E-07
U-235	2.0E-01	2.5E-08	5.0E-09
U-236	1.2E+00	2.5E-08	3.0E-08
U-238	2.5E+00	5.2E-11	1.3E-10
		ILCR Summation =	2.4E-07

Table I.IV-43
Summary of Intake Quantitation (chemicals)
Trespassing Child Future Land Use With Federal Ownership (age 7-18)
Via Incidental Ingestion of Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times IR}{BW \times AT}$

IRs	Ingestion rate of soil (RAGS, 1989)	25 mg/day
CF	Conversion factor	1.00E-06 kg/mg
EF	Exposure frequency	52 days/year
EDn	Exposure duration for non-carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/kg
4,4-DDE	NA	mg/kg
Antimony	5.4E+00	mg/kg
Aroclor-1221	NA	mg/kg
Aroclor-1248	NA	mg/kg
Aroclor-1254	NA	mg/kg
Aroclor-1260	NA	mg/kg
Arsenic	5.1E+00	mg/kg
Barium	9.7E+01	mg/kg
Beryllium	7.6E-01	mg/kg
Boron	1.1E+02	mg/kg
Cadmium	3.5E+00	mg/kg
Carbazole	NA	mg/kg
Chromium	1.6E+01	mg/kg
Cobalt	1.2E+01	mg/kg
Copper	2.0E+01	mg/kg

Compound	Concentration	Units
Cyanide	2.5E-01	mg/kg
Endrin	NA	mg/kg
Lead	2.4E+01	mg/kg
Manganese	9.8E+02	mg/kg
Mercury	2.1E-01	mg/kg
Molybdenum	6.5E+00	mg/kg
Nickel	2.3E+01	mg/kg
Selenium	6.3E-01	mg/kg
Silver	6.0E+00	mg/kg
Tetrachlordibenzo-p-dioxin	3.5E-08	mg/kg
Thallium	5.6E-01	mg/kg
Thorium	NA	mg/kg
Uranium	NA	mg/kg
Vanadium	2.6E+01	mg/kg
Zinc	6.4E+01	mg/kg

References

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Table I.IV-43 (continued)
Summary of Risk Characterization (chemicals)
Trespassing Child Future Land Use With Federal Ownership (age 7-18)
Via Incidental Ingestion of Soil/Sediment

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	4.4E-07	4.0E-04	1.1E-03
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	4.2E-07	3.0E-04	1.4E-03
Barium	8.1E-06	7.0E-02	1.2E-04
Beryllium	6.3E-08	5.0E-03	1.3E-05
Boron	9.3E-06	9.0E-02	1.0E-04
Cadmium	2.9E-07	1.0E-03	2.9E-04
Carbazole	NA	NA	NA
Chromium	1.4E-06	5.0E-03	2.7E-04
Cobalt	1.0E-06	6.0E-02	1.7E-05
Copper	1.7E-06	NA	NA
Cyanide	2.1E-08	2.0E-02	1.0E-06
Endrin	NA	3.0E-04	NA
Lead	1.9E-06	NA	NA
Manganese	8.1E-05	1.4E-01	5.8E-04
Mercury	1.8E-08	3.0E-04	5.9E-05
Molybdenum	5.4E-07	5.0E-03	1.1E-04
Nickel	1.9E-06	2.0E-02	9.4E-05
Selenium	5.2E-08	5.0E-03	1.0E-05
Silver	5.0E-07	5.0E-03	1.0E-04
Tetrachlordibenzo-p-dioxin	2.9E-15	NA	NA
Thallium	4.6E-08	8.0E-05	5.8E-04
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	NA
Vanadium	2.2E-06	7.0E-03	3.1E-04
Zinc	5.3E-06	3.0E-01	1.8E-05
	HQ Summation =		5.2E-03

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	7.6E-08	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	7.2E-08	1.8E+00	1.3E-07
Barium	1.4E-06	NA	NA
Beryllium	1.1E-08	4.3E+00	4.6E-08
Boron	1.6E-06	NA	NA
Cadmium	4.9E-08	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	2.3E-07	NA	NA
Cobalt	1.7E-07	NA	NA
Copper	2.9E-07	NA	NA
Cyanide	3.5E-09	NA	NA
Endrin	NA	NA	NA
Lead	3.3E-07	NA	NA
Manganese	1.4E-05	NA	NA
Mercury	3.0E-09	NA	NA
Molybdenum	9.2E-08	NA	NA
Nickel	3.2E-07	NA	NA
Selenium	9.0E-09	NA	NA
Silver	8.6E-08	NA	NA
Tetrachlordibenzo-p-dioxin	4.9E-16	1.5E+05	7.4E-11
Thallium	7.9E-09	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	3.7E-07	NA	NA
Zinc	9.1E-07	NA	NA
	ILCR Summation =		1.8E-07

Table I.IV–44
Summary of Intake and Risk Quantitation (Radionuclides)
Trespassing Child Future Land Use With Federal Ownership (age 7–18)
Via Incidental Ingestion of Soil/Sediment

Intake Equation = CS X EF X EDn X FI X IR

IRs	Ingestion rate of soil (RAGS, 1989)	25 mg/day
EF	Exposure frequency	52 days/year
EDn	Exposure Duration	12 Year
FI	Fractional Intake	1 (unitless)
CS	Concentration of radionuclides in soil	(see table below)

Cs–137	5.8E–04	pCi/mg	Ru–106	1.3E–04	pCi/mg
Np–237	8.4E–05	pCi/mg	Sr–90	8.3E–04	pCi/mg
Pa–231	NA	pCi/mg	Tc–99	1.9E–03	pCi/mg
Pb–210	1.1E–03	pCi/mg	Th–228	4.0E–04	pCi/mg
Pu–238	9.1E–05	pCi/mg	Th–230	5.9E–05	pCi/mg
Pu–239	1.3E–05	pCi/mg	Th–232	6.0E–04	pCi/mg
Pu–240	4.6E–05	pCi/mg	U–234	2.1E–02	pCi/mg
Ra–226	4.0E–04	pCi/mg	U–235	9.3E–04	pCi/mg
Ra–228	7.0E–04	pCi/mg	U–236	6.9E–03	pCi/mg
Rn–222	NA	pCi/mg	U–238	1.4E–02	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs–137	9.1E+00	2.8E–11	2.6E–10
Np–237	1.3E+00	2.2E–10	2.9E–10
Pa–231	NA	9.2E–11	NA
Pb–210	1.6E+01	6.6E–10	1.1E–08
Pu–238	1.4E+00	2.2E–10	3.1E–10
Pu–239	2.0E–01	2.3E–10	4.5E–11
Pu–240	7.1E–01	2.3E–10	1.6E–10
Ra–226	6.2E+00	1.2E–10	7.5E–10
Ra–228	1.1E+01	1.0E–10	1.1E–09
Rn–222	NA	1.7E–12	NA
Ru–106	2.1E+00	9.5E–12	2.0E–11
Sr–90	1.3E+01	3.6E–11	4.7E–10
Tc–99	2.9E+01	1.3E–12	3.8E–11
Th–228	6.2E+00	5.5E–11	3.4E–10
Th–230	9.2E–01	1.3E–11	1.2E–11
Th–232	9.3E+00	1.2E–11	1.1E–10
U–234	3.2E+02	1.6E–11	5.1E–09
U–235	1.5E+01	1.6E–11	2.3E–10
U–236	1.1E+02	1.5E–11	1.6E–09
U–238	2.2E+02	2.8E–11	6.0E–09
		ILCR Summation =	2.8E–08

Table I.IV–45
Summary of Intake and Risk Quantitation (Radionuclides)
Trespassing Child Future Land Use With Federal Ownership (age7–18)
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	12	Year
FI	Fractional intake for radionuclides	1	(Unitless)
Cs	Concentration of radionuclides in surface water		(see table below)

Cs–137	NA	pCi/l	Ru–106	NA	pCi/l
Np–237	NA	pCi/l	Sr–90	NA	pCi/l
Pa–231	NA	pCi/l	Tc–99	8.8E+02	pCi/l
Pb–210	NA	pCi/l	Th–228	NA	pCi/l
Pu–238	NA	pCi/l	Th–230	NA	pCi/l
Pu–239	NA	pCi/l	Th–232	NA	pCi/l
Pu–240	NA	pCi/l	U–234	2.0E+01	pCi/l
Ra–226	NA	pCi/l	U–235	5.3E–01	pCi/l
Ra–228	NA	pCi/l	U–236	2.2E–01	pCi/l
Rn–222	NA	pCi/l	U–238	1.2E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs–137	NA	2.8E–11	NA
Np–237	NA	2.2E–10	NA
Pa–231	NA	9.2E–11	NA
Pb–210	NA	6.6E–10	NA
Pu–238	NA	2.2E–10	NA
Pu–239	NA	2.3E–10	NA
Pu–240	NA	2.3E–10	NA
Ra–226	NA	1.2E–10	NA
Ra–228	NA	1.0E–10	NA
Rn–222	NA	1.7E–12	NA
Ru–106	NA	9.5E–12	NA
Sr–90	NA	3.6E–11	NA
Tc–99	2.6E+03	1.3E–12	3.4E–09
Th–228	NA	5.5E–11	NA
Th–230	NA	1.3E–11	NA
Th–232	NA	1.2E–11	NA
U–234	5.9E+01	1.6E–11	9.5E–10
U–235	1.6E+00	1.6E–11	2.5E–11
U–236	6.5E–01	1.5E–11	9.7E–12
U–238	3.5E+01	2.8E–11	9.9E–10
		ILCR Summation =	5.3E–09

Table I.IV-46
Summary of Intake Quantitation (chemicals)
Trespassing Child Future Land Use With Federal Ownership (age 7-18)
Via Dermal Contact with Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

SA	Surface area of exposed skin (50th percentile, hands only)	4200 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	52 days/year
EDn	Exposure duration for non-carcinogens	12 Year
EDc	Exposure duration for carcinogens	12 Year
BW	Body weight	43 kg
ATc	Average time for carcinogens (lifetime)	25550 days
ATn	Average time for non-carcinogens (EDn x 365)	4380 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	ABS	Concentrati	Units
2-Methylnaphthalene	3.0E-01	NA	mg/kg
4,4-DDE	3.0E-01	NA	mg/kg
Antimony	1.0E-02	5.4E+00	mg/kg
Aroclor-1221	6.0E-02	NA	mg/kg
Aroclor-1248	6.0E-02	NA	mg/kg
Aroclor-1254	6.0E-02	NA	mg/kg
Aroclor-1260	6.0E-02	NA	mg/kg
Arsenic	1.0E-03	5.1E+00	mg/kg
Barium	1.0E-02	9.7E+01	mg/kg
Beryllium	1.0E-02	7.6E-01	mg/kg
Boron	1.0E-02	1.1E+02	mg/kg
Cadmium	1.0E-02	3.5E+00	mg/kg
Carbazole	3.0E-01	NA	mg/kg
Chromium	1.0E-02	1.6E+01	mg/kg
Cobalt	1.0E-02	1.2E+01	mg/kg
Copper	1.0E-03	2.0E+01	mg/kg

Compound		Concentrati	Units
Cyanide	1.0E-02	2.5E-01	mg/kg
Endrin	3.0E-01	NA	mg/kg
Lead	1.0E-02	2.4E+01	mg/kg
Manganese	1.0E-02	9.8E+02	mg/kg
Mercury	5.0E-02	2.1E-01	mg/kg
Molybdenum	1.0E-02	6.5E+00	mg/kg
Nickel	5.0E-04	2.3E+01	mg/kg
Selenium	1.0E-02	6.3E-01	mg/kg
Silver	1.0E-02	6.0E+00	mg/kg
Tetrachlordibenzo-p-dioxin	3.0E-02	3.5E-08	mg/kg
Thallium	1.0E-02	5.6E-01	mg/kg
Thorium	1.0E-02	NA	mg/kg
Uranium	1.0E-02	NA	mg/kg
Vanadium	1.0E-03	2.6E+01	mg/kg
Zinc	1.0E-02	6.4E+01	mg/kg

References

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Table I.IV-46 (continued)
Summary of Risk Characterization (chemicals)
Trespassing Child Future Land Use With Federal Ownership (age 7-18)
Via Dermal Contact with Soil/Sediment

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	7.4E-07	6.0E-05	1.2E-02
Aroclor-1221	NA	5.3E-05	NA
Aroclor-1248	NA	5.3E-05	NA
Aroclor-1254	NA	5.3E-05	NA
Aroclor-1260	NA	5.3E-05	NA
Arsenic	7.1E-08	2.9E-04	2.5E-04
Barium	1.4E-05	6.4E-02	2.1E-04
Beryllium	1.1E-07	5.0E-05	2.1E-03
Boron	1.6E-05	4.5E-03	3.5E-03
Cadmium	4.8E-07	5.0E-05	9.7E-03
Carbazole	NA	NA	NA
Chromium	2.3E-06	2.3E-03	1.0E-03
Cobalt	1.7E-06	2.7E-02	6.2E-05
Copper	2.8E-07	2.2E-02	1.3E-05
Cyanide	3.5E-08	NA	NA
Endrin	NA	2.7E-04	NA
Lead	3.3E-06	NA	NA
Manganese	1.4E-04	4.2E-03	3.2E-02
Mercury	1.5E-07	4.5E-05	3.3E-03
Molybdenum	9.0E-07	1.9E-03	4.8E-04
Nickel	1.6E-07	2.0E-03	7.9E-05
Selenium	8.8E-08	4.0E-03	2.2E-05
Silver	8.4E-07	NA	NA
Tetrachlordibenzo-p-dioxin	1.5E-14	NA	NA
Thallium	7.8E-08	6.0E-05	1.3E-03
Thorium	NA	NA	NA
Uranium	NA	1.5E-04	NA
Vanadium	3.6E-07	3.5E-04	1.0E-03
Zinc	8.9E-06	7.5E-02	1.2E-04
	HQ Summation =		6.8E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.8E-01	NA
Antimony	1.3E-07	NA	NA
Aroclor-1221	NA	1.0E+01	NA
Aroclor-1248	NA	1.0E+01	NA
Aroclor-1254	NA	1.0E+01	NA
Aroclor-1260	NA	1.0E+01	NA
Arsenic	1.2E-08	1.9E+00	2.3E-08
Barium	2.3E-06	NA	NA
Beryllium	1.8E-08	4.3E+02	7.7E-06
Boron	2.7E-06	NA	NA
Cadmium	8.3E-08	NA	NA
Carbazole	NA	2.2E-02	NA
Chromium	3.9E-07	NA	NA
Cobalt	2.9E-07	NA	NA
Copper	4.8E-08	NA	NA
Cyanide	6.0E-09	NA	NA
Endrin	NA	NA	NA
Lead	5.6E-07	NA	NA
Manganese	2.3E-05	NA	NA
Mercury	2.6E-08	NA	NA
Molybdenum	1.5E-07	NA	NA
Nickel	2.7E-08	NA	NA
Selenium	1.5E-08	NA	NA
Silver	1.4E-07	NA	NA
Tetrachlordibenzo-p-dioxin	2.5E-15	3.0E+05	7.5E-10
Thallium	1.3E-08	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	6.2E-08	NA	NA
Zinc	1.5E-06	NA	NA
	ILCR Summation =		7.8E-06

Table I.IV–47
Summary of Risk Quantitation (Radionuclides)
Trespassing Child Future Land Use With Federal Ownership (age 7–18)
Via External Radiation

Exposure Equation = $[CR \times EF \times EDn \times ET_i \times (1-SH_i)] + [CR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.14 (unitless)
ED	Exposure duration	12 Year
ET_i	Fraction of day spent indoors	0 (unitless)
ET_o	Fraction of day spent outdoors	0.17 (unitless)
SH_i	Shield factor indoors	0.5 (unitless)
SH_o	Shield factor outdoors	0 (unitless)
CR	Radionuclide specific concentrations	(see table below)

Cs-137	5.8E-01	pCi/g	Ru-106	1.3E-01	pCi/g
Np-237	8.4E-02	pCi/g	Sr-90	8.3E-01	pCi/g
Pa-231	NA	pCi/g	Tc-99	1.9E+00	pCi/g
Pb-210	1.1E+00	pCi/g	Th-228	4.0E-01	pCi/g
Pu-238	9.1E-02	pCi/g	Th-230	5.9E-02	pCi/g
Pu-239	1.3E-02	pCi/g	Th-232	NA	pCi/g
Pu-240	4.6E-02	pCi/g	U-234	2.1E+01	pCi/g
Ra-226	4.0E-01	pCi/g	U-235	9.3E-01	pCi/g
Ra-228	7.0E-01	pCi/g	U-236	6.9E+00	pCi/g
Rn-222	NA	pCi/g	U-238	1.4E+01	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs-137	1.7E-01	2.0E-06	3.3E-07
Np-237	2.4E-02	4.3E-07	1.0E-08
Pa-231	NA	2.6E-08	NA
Pb-210	3.0E-01	1.6E-10	4.8E-11
Pu-238	2.6E-02	2.8E-11	7.3E-13
Pu-239	3.6E-03	1.7E-11	6.1E-14
Pu-240	1.3E-02	2.7E-11	3.5E-13
Ra-226	1.1E-01	6.0E-06	6.8E-07
Ra-228	2.0E-01	2.9E-06	5.8E-07
Rn-222	NA	5.9E-06	NA
Ru-106	3.8E-02	NA	NA
Sr-90	2.4E-01	NA	NA
Tc-99	5.3E-01	6.0E-13	3.2E-13
Th-228	1.1E-01	5.6E-06	6.4E-07
Th-230	1.7E-02	5.4E-11	9.1E-13
Th-232	NA	2.6E-11	NA
U-234	5.9E+00	3.0E-11	1.8E-10
U-235	2.7E-01	2.4E-07	6.4E-08
U-236	2.0E+00	2.4E-11	4.7E-11
U-238	3.9E+00	3.6E-08	1.4E-07
		ILCR Summation =	2.5E-06

Table I.IV-48
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
Via Inhalation of Particulates

Intake 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 x 365)	25550 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3
4,4-DDE	1.0E-09	mg/m^3
Antimony	5.5E-07	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3
Arsenic	5.3E-07	mg/m^3
Barium	8.7E-06	mg/m^3
Beryllium	6.0E-08	mg/m^3
Boron	1.1E-05	mg/m^3
Cadmium	3.7E-07	mg/m^3
Carbazole	7.3E-09	mg/m^3
Chromium	1.2E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3
Copper	2.0E-06	mg/m^3

Compound	Concentration	Units
Cyanide	2.3E-08	mg/m^3
Endrin	1.5E-10	mg/m^3
Lead	2.1E-06	mg/m^3
Manganese	7.7E-05	mg/m^3
Mercury	2.8E-08	mg/m^3
Molybdenum	5.4E-07	mg/m^3
Nickel	1.8E-06	mg/m^3
Selenium	6.5E-08	mg/m^3
Silver	6.5E-07	mg/m^3
Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Thallium	4.4E-08	mg/m^3
Thorium	2.3E-06	mg/m^3
Uranium	5.8E-05	mg/m^3
Vanadium	2.1E-06	mg/m^3
Zinc	6.3E-06	mg/m^3

References:

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Table I.IV-48 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	1.1E-09	NA	NA
4,4-DDE	2.8E-10	NA	NA
Antimony	1.5E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.4E-09	NA	NA
Aroclor-1260	5.3E-09	NA	NA
Arsenic	1.5E-07	NA	NA
Barium	2.4E-06	1.0E-04	2.4E-02
Beryllium	1.6E-08	NA	NA
Boron	3.0E-06	5.7E-03	5.3E-04
Cadmium	1.0E-07	NA	NA
Carbazole	2.0E-09	NA	NA
Chromium	3.3E-07	NA	NA
Cobalt	2.6E-07	3.0E-07	8.5E-01
Copper	5.6E-07	NA	NA
Cyanide	6.3E-09	NA	NA
Endrin	4.0E-11	NA	NA
Lead	5.8E-07	NA	NA
Manganese	2.1E-05	1.1E-04	1.9E-01
Mercury	7.6E-09	8.6E-05	8.8E-05
Molybdenum	1.5E-07	NA	NA
Nickel	4.9E-07	NA	NA
Selenium	1.8E-08	NA	NA
Silver	1.8E-07	NA	NA
Tetrachlordibenzo-p-dioxin	5.6E-15	NA	NA
Thallium	1.2E-08	NA	NA
Thorium	6.3E-07	NA	NA
Uranium	1.6E-05	NA	NA
Vanadium	5.8E-07	NA	NA
Zinc	1.7E-06	NA	NA
	HQ Summation =		1.1E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	1.1E-09	NA	NA
4,4-DDE	2.8E-10	NA	NA
Antimony	1.5E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.4E-09	NA	NA
Aroclor-1260	5.3E-09	NA	NA
Arsenic	1.5E-07	1.5E+01	2.2E-06
Barium	2.4E-06	NA	NA
Beryllium	1.6E-08	8.4E+00	1.4E-07
Boron	3.0E-06	NA	NA
Cadmium	1.0E-07	6.1E+00	6.3E-07
Carbazole	2.0E-09	NA	NA
Chromium	3.3E-07	4.1E+01	1.4E-05
Cobalt	2.6E-07	NA	NA
Copper	5.6E-07	NA	NA
Cyanide	6.3E-09	NA	NA
Endrin	4.0E-11	NA	NA
Lead	5.8E-07	NA	NA
Manganese	2.1E-05	NA	NA
Mercury	7.6E-09	NA	NA
Molybdenum	1.5E-07	NA	NA
Nickel	4.9E-07	8.4E-01	4.1E-07
Selenium	1.8E-08	NA	NA
Silver	1.8E-07	NA	NA
Tetrachlordibenzo-p-dioxin	5.6E-15	1.5E+05	8.5E-10
Thallium	1.2E-08	NA	NA
Thorium	6.3E-07	NA	NA
Uranium	1.6E-05	NA	NA
Vanadium	5.8E-07	NA	NA
Zinc	1.7E-06	NA	NA
	ILCR Summation =		1.7E-05

Table I.IV–49
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Future Land Use With Federal Ownership
Via Inhalation of Gases and Particulates

Intake 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)

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	2.3E+01	1.9E-11	4.4E-10
Np-237	9.6E+00	2.9E-08	2.8E-07
Pa-231	9.8E+00	3.6E-08	3.5E-07
Pb-210	4.1E+01	4.0E-09	1.6E-07
Pu-238	1.5E+01	3.9E-08	5.8E-07
Pu-239	3.7E+00	3.8E-08	1.4E-07
Pu-240	1.4E+01	3.8E-08	5.1E-07
Ra-226	1.5E+01	3.0E-09	4.6E-08
Ra-228	2.7E+01	6.9E-10	1.9E-08
Rn-222	1.3E+06	7.7E-12	1.0E-05
Ru-106	4.1E+00	4.4E-10	1.8E-09
Sr-90	3.9E+01	6.2E-11	2.4E-09
Tc-99	1.9E+02	8.3E-12	1.6E-09
Th-228	1.8E+01	7.8E-08	1.4E-06
Th-230	1.3E+02	2.9E-08	3.7E-06
Th-232	4.6E+01	2.8E-08	1.3E-06
U-234	1.2E+03	2.6E-08	3.0E-05
U-235	4.8E+01	2.5E-08	1.2E-06
U-236	2.8E+02	2.5E-08	7.1E-06
U-238	5.9E+02	5.2E-11	3.1E-08
		ILCR Summation =	5.7E-05

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Table I.IV-50
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
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
2-Methylnaphthalene	NA	mg/l	Cyanide	NA	mg/l
4,4-DDE	NA	mg/l	Endrin	NA	mg/l
Antimony	6.9E-08	mg/l	Lead	NA	mg/l
Aroclor-1221	1.0E-27	mg/l	Manganese	NA	mg/l
Aroclor-1248	NA	mg/l	Mercury	NA	mg/l
Aroclor-1254	NA	mg/l	Molybdenum	NA	mg/l
Aroclor-1260	NA	mg/l	Nickel	NA	mg/l
Arsenic	NA	mg/l	Selenium	NA	mg/l
Barium	NA	mg/l	Silver	NA	mg/l
Beryllium	NA	mg/l	Tetrachlordibenzo-p-dioxin	NA	mg/l
Boron	NA	mg/l	Thallium	NA	mg/l
Cadmium	1.7E-24	mg/l	Thorium	NA	mg/l
Carbazole	NA	mg/l	Uranium	NA	mg/l
Chromium	NA	mg/l	Vanadium	NA	mg/l
Cobalt	NA	mg/l	Zinc	NA	mg/l
Copper	NA	mg/l			

References

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Table I.IV-50
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	1.9E-09	4.0E-04	4.7E-06
Aroclor-1221	2.8E-29	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	NA	3.0E-04	0.0E+00
Barium	NA	7.0E-02	0.0E+00
Beryllium	NA	5.0E-03	0.0E+00
Boron	NA	9.0E-02	0.0E+00
Cadmium	4.7E-26	1.0E-03	4.7E-23
Carbazole	NA	NA	NA
Chromium	NA	5.0E-03	0.0E+00
Cobalt	NA	6.0E-02	0.0E+00
Copper	NA	NA	NA
Cyanide	NA	2.0E-02	0.0E+00
Endrin	NA	3.0E-04	0.0E+00
Lead	NA	NA	NA
Manganese	NA	1.4E-01	0.0E+00
Mercury	NA	3.0E-04	0.0E+00
Molybdenum	NA	5.0E-03	0.0E+00
Nickel	NA	2.0E-02	0.0E+00
Selenium	NA	5.0E-03	0.0E+00
Silver	NA	5.0E-03	0.0E+00
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	NA	8.0E-05	0.0E+00
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	0.0E+00
Vanadium	NA	7.0E-03	0.0E+00
Zinc	NA	3.0E-01	0.0E+00
	HQ Summation =		4.7E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	1.9E-09	NA	0.0E+00
Aroclor-1221	2.8E-29	7.7E+00	2.2E-28
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	NA	1.8E+00	NA
Barium	NA	NA	NA
Beryllium	NA	4.3E+00	NA
Boron	NA	NA	NA
Cadmium	4.7E-26	NA	0.0E+00
Carbazole	NA	2.0E-02	NA
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	NA	NA	NA
Cyanide	NA	NA	NA
Endrin	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Molybdenum	NA	NA	NA
Nickel	NA	NA	NA
Selenium	NA	NA	NA
Silver	NA	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	NA	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	NA	NA	NA
	ILCR Summation =		2.2E-28

Table I.IV-51
Summary of Intake and Risk Quantitation (Radionuclides)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
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	

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	8.0E-02	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	1.2E+03	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	2.6E+01	pCi/l
Ra-226	NA	pCi/l	U-235	7.0E-01	pCi/l
Ra-228	NA	pCi/l	U-236	2.9E-01	pCi/l
Rn-222	NA	pCi/l	U-238	1.6E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	3.9E+03	2.2E-10	8.7E-07
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	6.0E+07	1.3E-12	7.8E-05
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	1.3E+06	1.6E-11	2.1E-05
U-235	3.4E+04	1.6E-11	5.5E-07
U-236	1.4E+04	1.5E-11	2.1E-07
U-238	7.7E+05	2.8E-11	2.2E-05
		ILCR Summation =	1.2E-04

Table I.IV-52
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
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	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (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
2-Methylnaphthalene	0.0E+00	mg/kg
4,4-DDE	5.3E-10	mg/kg
Antimony	9.2E-09	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	9.6E-09	mg/kg
Aroclor-1260	6.5E-09	mg/kg
Arsenic	1.1E-08	mg/kg
Barium	1.4E-08	mg/kg
Beryllium	6.2E-10	mg/kg
Boron	1.1E-07	mg/kg
Cadmium	2.4E-09	mg/kg
Carbazole	0.0E+00	mg/kg
Chromium	7.0E-08	mg/kg
Cobalt	1.9E-07	mg/kg
Copper	2.2E-07	mg/kg

Compound	Concentration	Units
Cyanide	1.4E-14	mg/kg
Endrin	1.8E-11	mg/kg
Lead	6.7E-09	mg/kg
Manganese	3.2E-07	mg/kg
Mercury	7.6E-08	mg/kg
Molybdenum	3.4E-08	mg/kg
Nickel	1.1E-07	mg/kg
Selenium	1.0E-08	mg/kg
Silver	2.1E-08	mg/kg
Tetrachlordibenzo-p-dioxin	0.0E+00	mg/kg
Thallium	1.8E-08	mg/kg
Thorium	0.0E+00	mg/kg
Uranium	1.2E-07	mg/kg
Vanadium	5.5E-08	mg/kg
Zinc	9.0E-06	mg/kg

References

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Table I.IV-52 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	5.4E-13	NA	NA
Antimony	9.4E-12	4.0E-04	2.4E-08
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.9E-12	NA	NA
Aroclor-1260	6.7E-12	NA	NA
Arsenic	1.2E-11	3.0E-04	3.9E-08
Barium	1.5E-11	7.0E-02	2.1E-10
Beryllium	6.4E-13	5.0E-03	1.3E-10
Boron	1.2E-10	9.0E-02	1.3E-09
Cadmium	2.5E-12	1.0E-03	2.5E-09
Carbazole	NA	NA	NA
Chromium	7.2E-11	5.0E-03	1.4E-08
Cobalt	2.0E-10	6.0E-02	3.3E-09
Copper	2.2E-10	NA	NA
Cyanide	1.4E-17	2.0E-02	7.0E-16
Endrin	1.9E-14	3.0E-04	6.3E-11
Lead	6.8E-12	NA	NA
Manganese	3.3E-10	1.4E-01	2.4E-09
Mercury	7.8E-11	3.0E-04	2.6E-07
Molybdenum	3.5E-11	5.0E-03	7.1E-09
Nickel	1.2E-10	2.0E-02	5.8E-09
Selenium	1.1E-11	5.0E-03	2.1E-09
Silver	2.1E-11	5.0E-03	4.2E-09
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	1.9E-11	8.0E-05	2.4E-07
Thorium	NA	NA	NA
Uranium	1.3E-10	3.0E-03	4.2E-08
Vanadium	5.7E-11	7.0E-03	8.1E-09
Zinc	9.3E-09	3.0E-01	3.1E-08
	HQ Summation =		6.8E-07

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	5.4E-13	3.4E-01	1.8E-13
Antimony	9.4E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	9.9E-12	7.7E+00	7.6E-11
Aroclor-1260	6.7E-12	7.7E+00	5.2E-11
Arsenic	1.2E-11	1.8E+00	2.1E-11
Barium	1.5E-11	NA	NA
Beryllium	6.4E-13	4.3E+00	2.8E-12
Boron	1.2E-10	NA	NA
Cadmium	2.5E-12	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	7.2E-11	NA	NA
Cobalt	2.0E-10	NA	NA
Copper	2.2E-10	NA	NA
Cyanide	1.4E-17	NA	NA
Endrin	1.9E-14	NA	NA
Lead	6.8E-12	NA	NA
Manganese	3.3E-10	NA	NA
Mercury	7.8E-11	NA	NA
Molybdenum	3.5E-11	NA	NA
Nickel	1.2E-10	NA	NA
Selenium	1.1E-11	NA	NA
Silver	2.1E-11	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	1.9E-11	NA	NA
Thorium	NA	NA	NA
Uranium	1.3E-10	NA	NA
Vanadium	5.7E-11	NA	NA
Zinc	9.3E-09	NA	NA
	ILCR Summation =		1.5E-10

Table I.IV–53
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Future Land Use With Federal Ownership
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs-137	1.01E-05	pCi/kg	Ru-106	0.00E+00	pCi/kg
Np-237	2.21E-04	pCi/kg	Sr-90	NA	pCi/kg
Pa-231	1.7E-05	pCi/kg	Tc-99	NA	pCi/kg
Pb-210	0.0E+00	pCi/kg	Th-228	1.39E-09	pCi/kg
Pu-238	1.6E-10	pCi/kg	Th-230	1.62E-08	pCi/kg
Pu-239	4.0E-11	pCi/kg	Th-232	5.88E-09	pCi/kg
Pu-240	1.4E-10	pCi/kg	U-234	2.62E-01	pCi/kg
Ra-226	5.1E-08	pCi/kg	U-235	6.96E-03	pCi/kg
Ra-228	8.9E-08	pCi/kg	U-236	2.87E-03	pCi/kg
Rn-222	0.0E+00	pCi/kg	U-238	1.57E-01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.9E-02	2.8E-11	5.2E-13
Np-237	4.1E-01	2.2E-10	8.9E-11
Pa-231	3.1E-02	9.2E-11	2.8E-12
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	2.9E-07	2.2E-10	6.4E-17
Pu-239	7.3E-08	2.3E-10	1.7E-17
Pu-240	2.6E-07	2.3E-10	6.1E-17
Ra-226	9.4E-05	1.2E-10	1.1E-14
Ra-228	1.6E-04	1.0E-10	1.6E-14
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	0.0E+00	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	NA	1.3E-12	NA
Th-228	2.6E-06	5.5E-11	1.4E-16
Th-230	3.0E-05	1.3E-11	3.9E-16
Th-232	1.1E-05	1.2E-11	1.3E-16
U-234	4.8E+02	1.6E-11	7.7E-09
U-235	1.3E+01	1.6E-11	2.0E-10
U-236	5.3E+00	1.5E-11	7.9E-11
U-238	2.9E+02	2.8E-11	8.1E-09
		ILCR Summation =	1.6E-08

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Table I.IV-54
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
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	0.3 l/day
FI	Fraction ingested from contaminated source	1 (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
2-Methylnaphthalene	NA	mg/kg
4,4-DDE	1.0E-10	mg/kg
Antimony	9.9E-10	mg/kg
Aroclor-1221	NA	mg/kg
Aroclor-1248	NA	mg/kg
Aroclor-1254	3.0E-09	mg/kg
Aroclor-1260	2.1E-09	mg/kg
Arsenic	3.4E-10	mg/kg
Barium	3.3E-08	mg/kg
Beryllium	5.6E-13	mg/kg
Boron	2.1E-07	mg/kg
Cadmium	4.4E-09	mg/kg
Carbazole	NA	mg/kg
Chromium	1.9E-08	mg/kg
Cobalt	1.9E-08	mg/kg
Copper	3.3E-08	mg/kg

Compound	Concentration	Units
Cyanide	4.4E-15	mg/kg
Endrin	2.7E-12	mg/kg
Lead	5.5E-09	mg/kg
Manganese	2.8E-07	mg/kg
Mercury	1.4E-10	mg/kg
Molybdenum	8.6E-09	mg/kg
Nickel	1.9E-08	mg/kg
Selenium	2.7E-09	mg/kg
Silver	1.4E-07	mg/kg
Tetrachlordibenzo-p-dioxin	NA	mg/kg
Thallium	9.2E-10	mg/kg
Thorium	NA	mg/kg
Uranium	3.7E-07	mg/kg
Vanadium	4.4E-10	mg/kg
Zinc	9.0E-07	mg/kg

References

Table I.IV-54 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.2E-13	NA	NA
Antimony	4.1E-12	4.0E-04	1.0E-08
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.2E-11	NA	NA
Aroclor-1260	8.5E-12	NA	NA
Arsenic	1.4E-12	3.0E-04	4.6E-09
Barium	1.4E-10	7.0E-02	1.9E-09
Beryllium	2.3E-15	5.0E-03	4.6E-13
Boron	8.8E-10	9.0E-02	9.7E-09
Cadmium	1.8E-11	1.0E-03	1.8E-08
Carbazole	NA	NA	NA
Chromium	7.9E-11	5.0E-03	1.6E-08
Cobalt	8.0E-11	6.0E-02	1.3E-09
Copper	1.3E-10	NA	NA
Cyanide	1.8E-17	2.0E-02	9.0E-16
Endrin	1.1E-14	3.0E-04	3.7E-11
Lead	2.3E-11	NA	NA
Manganese	1.2E-09	1.4E-01	8.3E-09
Mercury	5.6E-13	3.0E-04	1.9E-09
Molybdenum	3.5E-11	5.0E-03	7.1E-09
Nickel	7.8E-11	2.0E-02	3.9E-09
Selenium	1.1E-11	5.0E-03	2.2E-09
Silver	5.7E-10	5.0E-03	1.1E-07
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	3.8E-12	8.0E-05	4.7E-08
Thorium	NA	NA	NA
Uranium	1.5E-09	3.0E-03	5.0E-07
Vanadium	1.8E-12	7.0E-03	2.6E-10
Zinc	3.7E-09	3.0E-01	1.2E-08
	HQ Summation =		7.6E-07

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.2E-13	3.4E-01	1.4E-13
Antimony	4.1E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.2E-11	7.7E+00	9.6E-11
Aroclor-1260	8.5E-12	7.7E+00	6.5E-11
Arsenic	1.4E-12	1.8E+00	2.5E-12
Barium	1.4E-10	NA	NA
Beryllium	2.3E-15	4.3E+00	9.9E-15
Boron	8.8E-10	NA	NA
Cadmium	1.8E-11	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	7.9E-11	NA	NA
Cobalt	8.0E-11	NA	NA
Copper	1.3E-10	NA	NA
Cyanide	1.8E-17	NA	NA
Endrin	1.1E-14	NA	NA
Lead	2.3E-11	NA	NA
Manganese	1.2E-09	NA	NA
Mercury	5.6E-13	NA	NA
Molybdenum	3.5E-11	NA	NA
Nickel	7.8E-11	NA	NA
Selenium	1.1E-11	NA	NA
Silver	5.7E-10	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	3.8E-12	NA	NA
Thorium	NA	NA	NA
Uranium	1.5E-09	NA	NA
Vanadium	1.8E-12	NA	NA
Zinc	3.7E-09	NA	NA
	ILCR Summation =		1.6E-10

Table I.IV–55
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Future Land Use With Federal Ownership
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.3 l/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs-137	3.55E-06	pCi/l	Ru-106	7.81E-32	pCi/l
Np-237	2.41E-05	pCi/l	Sr-90	1.78E-27	pCi/l
Pa-231	1.0E-07	pCi/l	Tc-99	1.04E-18	pCi/l
Pb-210	NA	pCi/l	Th-228	1.78E-09	pCi/l
Pu-238	3.2E-11	pCi/l	Th-230	1.35E-08	pCi/l
Pu-239	7.9E-12	pCi/l	Th-232	4.90E-09	pCi/l
Pu-240	2.9E-11	pCi/l	U-234	9.43E-01	pCi/l
Ra-226	1.4E-07	pCi/l	U-235	2.51E-02	pCi/l
Ra-228	2.5E-07	pCi/l	U-236	1.03E-02	pCi/l
Rn-222	NA	pCi/l	U-238	5.65E-01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	2.6E-02	2.8E-11	7.3E-13
Np-237	1.8E-01	2.2E-10	3.9E-11
Pa-231	7.6E-04	9.2E-11	7.0E-14
Pb-210	NA	6.6E-10	NA
Pu-238	2.3E-07	2.2E-10	5.1E-17
Pu-239	5.8E-08	2.3E-10	1.3E-17
Pu-240	2.1E-07	2.3E-10	4.9E-17
Ra-226	1.0E-03	1.2E-10	1.2E-13
Ra-228	1.8E-03	1.0E-10	1.8E-13
Rn-222	NA	1.7E-12	NA
Ru-106	5.7E-28	9.5E-12	5.5E-39
Sr-90	1.3E-23	3.6E-11	4.7E-34
Tc-99	7.7E-15	1.3E-12	1.0E-26
Th-228	1.3E-05	5.5E-11	7.2E-16
Th-230	9.9E-05	1.3E-11	1.3E-15
Th-232	3.6E-05	1.2E-11	4.3E-16
U-234	6.9E+03	1.6E-11	1.1E-07
U-235	1.8E+02	1.6E-11	2.9E-09
U-236	7.6E+01	1.5E-11	1.1E-09
U-238	4.2E+03	2.8E-11	1.2E-07
		ILCR Summation =	2.3E-07

Table I.IV-56
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
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
2-Methylnaphthalene	5.3E-10	mg/kg
4,4-DDE	1.4E-10	mg/kg
Antimony	7.4E-08	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	4.7E-09	mg/kg
Aroclor-1260	2.6E-09	mg/kg
Arsenic	7.3E-08	mg/kg
Barium	1.2E-06	mg/kg
Beryllium	8.1E-09	mg/kg
Boron	1.6E-06	mg/kg
Cadmium	5.2E-08	mg/kg
Carbazole	1.0E-09	mg/kg
Chromium	1.7E-07	mg/kg
Cobalt	1.3E-07	mg/kg
Copper	2.8E-07	mg/kg

Compound	Concentration	Units
Cyanide	3.1E-09	mg/kg
Endrin	2.0E-11	mg/kg
Lead	2.9E-07	mg/kg
Manganese	1.0E-05	mg/kg
Mercury	3.8E-09	mg/kg
Molybdenum	8.1E-08	mg/kg
Nickel	2.4E-07	mg/kg
Selenium	8.9E-09	mg/kg
Silver	8.8E-08	mg/kg
Tetrachlordibenzo-p-dioxin	2.8E-15	mg/kg
Thallium	6.0E-09	mg/kg
Thorium	3.1E-07	mg/kg
Uranium	7.9E-06	mg/kg
Vanadium	2.9E-07	mg/kg
Zinc	9.8E-07	mg/kg

References

Table I.IV-56 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use With Federal Ownership
Via Ingestion of Vegetables and Fruits

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	1.2E-13	NA	NA
Antimony	6.2E-11	4.0E-04	1.6E-07
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	3.9E-12	NA	NA
Aroclor-1260	2.2E-12	NA	NA
Arsenic	6.1E-11	3.0E-04	2.0E-07
Barium	9.9E-10	7.0E-02	1.4E-08
Beryllium	6.8E-12	5.0E-03	1.4E-09
Boron	1.4E-09	9.0E-02	1.5E-08
Cadmium	4.4E-11	1.0E-03	4.4E-08
Carbazole	8.3E-13	NA	NA
Chromium	1.4E-10	5.0E-03	2.8E-08
Cobalt	1.1E-10	6.0E-02	1.8E-09
Copper	2.3E-10	NA	NA
Cyanide	2.6E-12	2.0E-02	1.3E-10
Endrin	1.7E-14	3.0E-04	5.6E-11
Lead	2.4E-10	NA	NA
Manganese	8.7E-09	1.4E-01	6.2E-08
Mercury	3.2E-12	3.0E-04	1.1E-08
Molybdenum	6.7E-11	5.0E-03	1.3E-08
Nickel	2.0E-10	2.0E-02	1.0E-08
Selenium	7.4E-12	5.0E-03	1.5E-09
Silver	7.4E-11	5.0E-03	1.5E-08
Tetrachlordibenzo-p-dioxin	2.3E-18	NA	NA
Thallium	5.0E-12	8.0E-05	6.2E-08
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	3.0E-03	2.2E-06
Vanadium	2.4E-10	7.0E-03	3.4E-08
Zinc	8.2E-10	3.0E-01	2.7E-09
	HQ Summation =		2.9E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	1.2E-13	3.4E-01	4.0E-14
Antimony	6.2E-11	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	3.9E-12	7.7E+00	3.0E-11
Aroclor-1260	2.2E-12	7.7E+00	1.7E-11
Arsenic	6.1E-11	1.8E+00	1.1E-10
Barium	9.9E-10	NA	NA
Beryllium	6.8E-12	4.3E+00	2.9E-11
Boron	1.4E-09	NA	NA
Cadmium	4.4E-11	NA	NA
Carbazole	8.3E-13	2.0E-02	1.7E-14
Chromium	1.4E-10	NA	NA
Cobalt	1.1E-10	NA	NA
Copper	2.3E-10	NA	NA
Cyanide	2.6E-12	NA	NA
Endrin	1.7E-14	NA	NA
Lead	2.4E-10	NA	NA
Manganese	8.7E-09	NA	NA
Mercury	3.2E-12	NA	NA
Molybdenum	6.7E-11	NA	NA
Nickel	2.0E-10	NA	NA
Selenium	7.4E-12	NA	NA
Silver	7.4E-11	NA	NA
Tetrachlordibenzo-p-dioxin	2.3E-18	1.5E+05	3.5E-13
Thallium	5.0E-12	NA	NA
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	NA	NA
Vanadium	2.4E-10	NA	NA
Zinc	8.2E-10	NA	NA
	ILCR Summation =		1.9E-10

Table I.IV–57
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Future Land Use With Federal Ownership
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	

Cs-137	6.51E-06	pCi/kg	Ru-106	4.38E-17	pCi/kg
Np-237	2.65E-06	pCi/kg	Sr-90	4.09E-16	pCi/kg
Pa-231	2.7E-06	pCi/kg	Tc-99	2.25E-07	pCi/kg
Pb-210	1.1E-05	pCi/kg	Th-228	4.75E-06	pCi/kg
Pu-238	4.1E-06	pCi/kg	Th-230	3.51E-05	pCi/kg
Pu-239	1.0E-06	pCi/kg	Th-232	1.28E-05	pCi/kg
Pu-240	3.8E-06	pCi/kg	U-234	1.28E+02	pCi/kg
Ra-226	4.2E-06	pCi/kg	U-235	3.41E+00	pCi/kg
Ra-228	7.3E-06	pCi/kg	U-236	1.40E+00	pCi/kg
Rn-222	3.6E-01	pCi/kg	U-238	7.68E+01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	9.7E-03	2.8E-11	2.7E-13
Np-237	4.0E-03	2.2E-10	8.7E-13
Pa-231	4.0E-03	9.2E-11	3.7E-13
Pb-210	1.7E-02	6.6E-10	1.1E-11
Pu-238	6.1E-03	2.2E-10	1.3E-12
Pu-239	1.5E-03	2.3E-10	3.5E-13
Pu-240	5.6E-03	2.3E-10	1.3E-12
Ra-226	6.2E-03	1.2E-10	7.5E-13
Ra-228	1.1E-02	1.0E-10	1.1E-12
Rn-222	5.4E+02	1.7E-12	9.2E-10
Ru-106	6.6E-14	9.5E-12	6.2E-25
Sr-90	6.1E-13	3.6E-11	2.2E-23
Tc-99	3.4E-04	1.3E-12	4.4E-16
Th-228	7.1E-03	5.5E-11	3.9E-13
Th-230	5.2E-02	1.3E-11	6.8E-13
Th-232	1.9E-02	1.2E-11	2.3E-13
U-234	1.9E+05	1.6E-11	3.1E-06
U-235	5.1E+03	1.6E-11	8.1E-08
U-236	2.1E+03	1.5E-11	3.1E-08
U-238	1.1E+05	2.8E-11	3.2E-06
		ILCR Summation =	6.4E-06

Table I.IV-58
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Inhalation of particulates

Intake 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 x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3
4,4-DDE	1.0E-09	mg/m^3
Antimony	5.5E-07	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3
Arsenic	5.3E-07	mg/m^3
Barium	8.7E-06	mg/m^3
Beryllium	6.0E-08	mg/m^3
Boron	1.1E-05	mg/m^3
Cadmium	3.7E-07	mg/m^3
Carbazole	7.3E-09	mg/m^3
Chromium	1.2E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3
Copper	2.0E-06	mg/m^3

Compound	Concentration	Units
Cyanide	2.3E-08	mg/m^3
Endrin	1.5E-10	mg/m^3
Lead	2.1E-06	mg/m^3
Manganese	7.7E-05	mg/m^3
Mercury	2.8E-08	mg/m^3
Molybdenum	5.4E-07	mg/m^3
Nickel	1.8E-06	mg/m^3
Selenium	6.5E-08	mg/m^3
Silver	6.5E-07	mg/m^3
Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Thallium	4.4E-08	mg/m^3
Thorium	2.3E-06	mg/m^3
Uranium	5.8E-05	mg/m^3
Vanadium	2.1E-06	mg/m^3
Zinc	6.3E-06	mg/m^3

References

Table I.IV-58 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	3.0E-09	NA	NA
4,4-DDE	7.9E-10	NA	NA
Antimony	4.2E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.6E-08	NA	NA
Aroclor-1260	1.5E-08	NA	NA
Arsenic	4.1E-07	NA	NA
Barium	6.7E-06	1.0E-04	6.7E-02
Beryllium	4.6E-08	NA	NA
Boron	8.5E-06	5.7E-03	1.5E-03
Cadmium	2.9E-07	NA	NA
Carbazole	5.6E-09	NA	NA
Chromium	9.4E-07	NA	NA
Cobalt	7.1E-07	3.0E-07	2.4E+00
Copper	1.6E-06	NA	NA
Cyanide	1.8E-08	NA	NA
Endrin	1.1E-10	NA	NA
Lead	1.6E-06	NA	NA
Manganese	5.9E-05	1.1E-04	5.3E-01
Mercury	2.1E-08	8.6E-05	2.5E-04
Molybdenum	4.1E-07	NA	NA
Nickel	1.4E-06	NA	NA
Selenium	5.0E-08	NA	NA
Silver	4.9E-07	NA	NA
Tetrachlordibenzo-p-dioxin	1.6E-14	NA	NA
Thallium	3.4E-08	NA	NA
Thorium	1.8E-06	NA	NA
Uranium	4.5E-05	NA	NA
Vanadium	1.6E-06	NA	NA
Zinc	4.8E-06	NA	NA
	Hazard Quotient Sum =		3.0E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	2.6E-10	NA	NA
4,4-DDE	6.8E-11	NA	NA
Antimony	3.6E-08	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.2E-09	NA	NA
Aroclor-1260	1.3E-09	NA	NA
Arsenic	3.5E-08	1.5E+01	5.3E-07
Barium	5.7E-07	NA	NA
Beryllium	3.9E-09	8.4E+00	3.3E-08
Boron	7.3E-07	NA	NA
Cadmium	2.5E-08	6.1E+00	1.5E-07
Carbazole	4.8E-10	NA	NA
Chromium	8.0E-08	4.1E+01	3.3E-06
Cobalt	6.1E-08	NA	NA
Copper	1.3E-07	NA	NA
Cyanide	1.5E-09	NA	NA
Endrin	9.7E-12	NA	NA
Lead	1.4E-07	NA	NA
Manganese	5.0E-06	NA	NA
Mercury	1.8E-09	NA	NA
Molybdenum	3.6E-08	NA	NA
Nickel	1.2E-07	8.4E-01	9.8E-08
Selenium	4.3E-09	NA	NA
Silver	4.2E-08	NA	NA
Tetrachlordibenzo-p-dioxin	1.4E-15	1.5E+05	2.0E-10
Thallium	2.9E-09	NA	NA
Thorium	1.5E-07	NA	NA
Uranium	3.8E-06	NA	NA
Vanadium	1.4E-07	NA	NA
Zinc	4.1E-07	NA	NA
	ILCR Summation =		4.1E-06

Table I.IV–59
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Inhalation of Gases and Particulates

Intake 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)

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.2E+00	1.9E-11	2.3E-11
Np-237	4.9E-01	2.9E-08	1.4E-08
Pa-231	5.0E-01	3.6E-08	1.8E-08
Pb-210	2.1E+00	4.0E-09	8.3E-09
Pu-238	7.6E-01	3.9E-08	3.0E-08
Pu-239	1.9E-01	3.8E-08	7.3E-09
Pu-240	7.0E-01	3.8E-08	2.6E-08
Ra-226	7.9E-01	3.0E-09	2.4E-09
Ra-228	1.4E+00	6.9E-10	9.5E-10
Rn-222	6.7E+04	7.7E-12	5.2E-07
Ru-106	2.1E-01	4.4E-10	9.2E-11
Sr-90	2.0E+00	6.2E-11	1.2E-10
Tc-99	9.8E+00	8.3E-12	8.1E-11
Th-228	9.0E-01	7.8E-08	7.0E-08
Th-230	6.5E+00	2.9E-08	1.9E-07
Th-232	2.4E+00	2.8E-08	6.6E-08
U-234	6.0E+01	2.6E-08	1.6E-06
U-235	2.5E+00	2.5E-08	6.1E-08
U-236	1.5E+01	2.5E-08	3.6E-07
U-238	3.0E+01	5.2E-11	1.6E-09
		ILCR Summation =	2.9E-06

Table I.IV-60
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Drinking Water Ingestion

Intake 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 x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/l
4,4-DDE	NA	mg/l
Antimony	6.90E-08	mg/l
Aroclor-1221	1.03E-27	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	NA	mg/l
Aroclor-1260	NA	mg/l
Arsenic	NA	mg/l
Barium	NA	mg/l
Beryllium	NA	mg/l
Boron	NA	mg/l
Cadmium	1.71E-24	mg/l
Carbazole	NA	mg/l
Chromium	NA	mg/l
Cobalt	NA	mg/l
Copper	NA	mg/l

Compound	Concentration	Units
Cyanide	NA	mg/l
Endrin	NA	mg/l
Lead	NA	mg/l
Manganese	NA	mg/l
Mercury	NA	mg/l
Molybdenum	NA	mg/l
Nickel	NA	mg/l
Selenium	NA	mg/l
Silver	NA	mg/l
Tetrachlordibenzo-p-dioxin	NA	mg/l
Thallium	NA	mg/l
Thorium	NA	mg/l
Uranium	NA	mg/l
Vanadium	NA	mg/l
Zinc	NA	mg/l

References

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Table I.IV-60
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	4.4E-09	4.0E-04	1.1E-05
Aroclor-1221	6.6E-29	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	NA	3.0E-04	0.0E+00
Barium	NA	7.0E-02	0.0E+00
Beryllium	NA	5.0E-03	0.0E+00
Boron	NA	9.0E-02	0.0E+00
Cadmium	1.1E-25	1.0E-03	1.1E-22
Carbazole	NA	NA	NA
Chromium	NA	5.0E-03	0.0E+00
Cobalt	NA	6.0E-02	0.0E+00
Copper	NA	NA	NA
Cyanide	NA	2.0E-02	0.0E+00
Endrin	NA	3.0E-04	0.0E+00
Lead	NA	NA	NA
Manganese	NA	1.4E-01	0.0E+00
Mercury	NA	3.0E-04	0.0E+00
Molybdenum	NA	5.0E-03	0.0E+00
Nickel	NA	2.0E-02	0.0E+00
Selenium	NA	5.0E-03	0.0E+00
Silver	NA	5.0E-03	0.0E+00
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	NA	8.0E-05	0.0E+00
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	0.0E+00
Vanadium	NA	7.0E-03	0.0E+00
Zinc	NA	3.0E-01	0.0E+00
	HQ Summation =		1.1E-05

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	3.8E-10	NA	0.0E+00
Aroclor-1221	5.6E-30	7.7E+00	4.3E-29
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	NA	1.8E+00	NA
Barium	NA	NA	NA
Beryllium	NA	4.3E+00	NA
Boron	NA	NA	NA
Cadmium	9.4E-27	NA	0.0E+00
Carbazole	NA	2.0E-02	NA
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	NA	NA	NA
Cyanide	NA	NA	NA
Endrin	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Molybdenum	NA	NA	NA
Nickel	NA	NA	NA
Selenium	NA	NA	NA
Silver	NA	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	NA	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	NA	NA	NA
	ILCR Summation =		4.3E-29

Table I.IV–61
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Ingestion of Drinking Water

Intake 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)

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	8.0E-02	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	1.2E+03	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	2.6E+01	pCi/l
Ra-226	NA	pCi/l	U-235	7.0E-01	pCi/l
Ra-228	NA	pCi/l	U-236	2.9E-01	pCi/l
Rn-222	NA	pCi/l	U-238	1.6E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	1.7E+02	2.2E-10	3.7E-08
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	2.6E+06	1.3E-12	3.3E-06
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	5.5E+04	1.6E-11	8.8E-07
U-235	1.5E+03	1.6E-11	2.3E-08
U-236	6.0E+02	1.5E-11	9.0E-09
U-238	3.3E+04	2.8E-11	9.2E-07
		ILCR Summation =	5.2E-06

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Table I.IV-62
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
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	0.029 kg/day
FI	Fraction ingested from contaminated source	1 (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 x 365)	2190 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	0.0E+00	mg/kg
4,4-DDE	5.3E-10	mg/kg
Antimony	9.2E-09	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	9.6E-09	mg/kg
Aroclor-1260	6.5E-09	mg/kg
Arsenic	1.1E-08	mg/kg
Barium	1.4E-08	mg/kg
Beryllium	6.2E-10	mg/kg
Boron	1.1E-07	mg/kg
Cadmium	2.4E-09	mg/kg
Carbazole	0.0E+00	mg/kg
Chromium	7.0E-08	mg/kg
Cobalt	1.9E-07	mg/kg
Copper	2.2E-07	mg/kg

Compound	Concentration	Units
Cyanide	1.4E-14	mg/kg
Endrin	1.8E-11	mg/kg
Lead	6.7E-09	mg/kg
Manganese	3.2E-07	mg/kg
Mercury	7.6E-08	mg/kg
Molybdenum	3.4E-08	mg/kg
Nickel	1.1E-07	mg/kg
Selenium	1.0E-08	mg/kg
Silver	2.1E-08	mg/kg
Tetrachlordibenzo-p-dioxin	0.0E+00	mg/kg
Thallium	1.8E-08	mg/kg
Thorium	0.0E+00	mg/kg
Uranium	1.2E-07	mg/kg
Vanadium	5.5E-08	mg/kg
Zinc	9.0E-06	mg/kg

References

Table I.IV-62 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	9.8E-13	NA	NA
Antimony	1.7E-11	4.0E-04	4.3E-08
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.8E-11	NA	NA
Aroclor-1260	1.2E-11	NA	NA
Arsenic	2.1E-11	3.0E-04	7.0E-08
Barium	2.6E-11	7.0E-02	3.7E-10
Beryllium	1.2E-12	5.0E-03	2.3E-10
Boron	2.1E-10	9.0E-02	2.3E-09
Cadmium	4.5E-12	1.0E-03	4.5E-09
Carbazole	NA	NA	NA
Chromium	1.3E-10	5.0E-03	2.6E-08
Cobalt	3.6E-10	6.0E-02	6.0E-09
Copper	4.0E-10	NA	NA
Cyanide	2.5E-17	2.0E-02	1.3E-15
Endrin	3.4E-14	3.0E-04	1.1E-10
Lead	1.2E-11	NA	NA
Manganese	6.0E-10	1.4E-01	4.3E-09
Mercury	1.4E-10	3.0E-04	4.7E-07
Molybdenum	6.4E-11	5.0E-03	1.3E-08
Nickel	2.1E-10	2.0E-02	1.0E-08
Selenium	1.9E-11	5.0E-03	3.8E-09
Silver	3.8E-11	5.0E-03	7.7E-09
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	3.4E-11	8.0E-05	4.3E-07
Thorium	NA	NA	NA
Uranium	2.3E-10	3.0E-03	7.5E-08
Vanadium	1.0E-10	7.0E-03	1.5E-08
Zinc	1.7E-08	3.0E-01	5.6E-08
	HQ Summation =		1.2E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	8.4E-14	3.4E-01	2.9E-14
Antimony	1.5E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.5E-12	7.7E+00	1.2E-11
Aroclor-1260	1.0E-12	7.7E+00	8.0E-12
Arsenic	1.8E-12	1.8E+00	3.2E-12
Barium	2.2E-12	NA	NA
Beryllium	9.9E-14	4.3E+00	4.3E-13
Boron	1.8E-11	NA	NA
Cadmium	3.9E-13	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	1.1E-11	NA	NA
Cobalt	3.1E-11	NA	NA
Copper	3.4E-11	NA	NA
Cyanide	2.2E-18	NA	NA
Endrin	2.9E-15	NA	NA
Lead	1.1E-12	NA	NA
Manganese	5.2E-11	NA	NA
Mercury	1.2E-11	NA	NA
Molybdenum	5.5E-12	NA	NA
Nickel	1.8E-11	NA	NA
Selenium	1.6E-12	NA	NA
Silver	3.3E-12	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	2.9E-12	NA	NA
Thorium	NA	NA	NA
Uranium	1.9E-11	NA	NA
Vanadium	8.8E-12	NA	NA
Zinc	1.4E-09	NA	NA
	ILCR Summation =		2.3E-11

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Table I.IV–63
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.029 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Cs-137	1.01E-05	pCi/kg	Ru-106	0.00E+00	pCi/kg
Np-237	2.21E-04	pCi/kg	Sr-90	NA	pCi/kg
Pa-231	1.7E-05	pCi/kg	Tc-99	NA	pCi/kg
Pb-210	0.0E+00	pCi/kg	Th-228	1.39E-09	pCi/kg
Pu-238	1.6E-10	pCi/kg	Th-230	1.62E-08	pCi/kg
Pu-239	4.0E-11	pCi/kg	Th-232	5.88E-09	pCi/kg
Pu-240	1.4E-10	pCi/kg	U-234	2.62E-01	pCi/kg
Ra-226	5.1E-08	pCi/kg	U-235	6.96E-03	pCi/kg
Ra-228	8.9E-08	pCi/kg	U-236	2.87E-03	pCi/kg
Rn-222	0.0E+00	pCi/kg	U-238	1.57E-01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	6.2E-04	2.8E-11	1.7E-14
Np-237	1.3E-02	2.2E-10	3.0E-12
Pa-231	1.0E-03	9.2E-11	9.3E-14
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	9.6E-09	2.2E-10	2.1E-18
Pu-239	2.4E-09	2.3E-10	5.6E-19
Pu-240	8.8E-09	2.3E-10	2.0E-18
Ra-226	3.1E-06	1.2E-10	3.7E-16
Ra-228	5.4E-06	1.0E-10	5.4E-16
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	0.0E+00	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	NA	1.3E-12	NA
Th-228	8.5E-08	5.5E-11	4.7E-18
Th-230	9.8E-07	1.3E-11	1.3E-17
Th-232	3.6E-07	1.2E-11	4.3E-18
U-234	1.6E+01	1.6E-11	2.6E-10
U-235	4.2E-01	1.6E-11	6.8E-12
U-236	1.7E-01	1.5E-11	2.6E-12
U-238	9.6E+00	2.8E-11	2.7E-10
		ILCR Summation =	5.4E-10

Table I.IV-64
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
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	0.68	l/day
FI	Fraction ingested from contaminated source	1	(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 x 365)	2190	days
CS	Concentration of chemicals in animal products		

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/l
4,4-DDE	1.0E-10	mg/l
Antimony	9.9E-10	mg/l
Aroclor-1221	NA	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	3.0E-09	mg/l
Aroclor-1260	2.1E-09	mg/l
Arsenic	3.4E-10	mg/l
Barium	3.3E-08	mg/l
Beryllium	5.6E-13	mg/l
Boron	2.1E-07	mg/l
Cadmium	4.4E-09	mg/l
Carbazole	NA	mg/l
Chromium	1.9E-08	mg/l
Cobalt	1.9E-08	mg/l
Copper	3.3E-08	mg/l

Compound	Concentration	Units
Cyanide	4.4E-15	mg/l
Endrin	2.7E-12	mg/l
Lead	5.5E-09	mg/l
Manganese	2.8E-07	mg/l
Mercury	1.4E-10	mg/l
Molybdenum	8.6E-09	mg/l
Nickel	1.9E-08	mg/l
Selenium	2.7E-09	mg/l
Silver	1.4E-07	mg/l
Tetrachlordibenzo-p-dioxin	NA	mg/l
Thallium	9.2E-10	mg/l
Thorium	NA	mg/l
Uranium	3.7E-07	mg/l
Vanadium	4.4E-10	mg/l
Zinc	9.0E-07	mg/l

References

Table I.IV-64 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.5E-12	NA	NA
Antimony	4.3E-11	4.0E-04	1.1E-07
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.3E-10	NA	NA
Aroclor-1260	8.9E-11	NA	NA
Arsenic	1.5E-11	3.0E-04	4.9E-08
Barium	1.4E-09	7.0E-02	2.0E-08
Beryllium	2.4E-14	5.0E-03	4.9E-12
Boron	9.3E-09	9.0E-02	1.0E-07
Cadmium	1.9E-10	1.0E-03	1.9E-07
Carbazole	NA	NA	NA
Chromium	8.3E-10	5.0E-03	1.7E-07
Cobalt	8.5E-10	6.0E-02	1.4E-08
Copper	1.4E-09	NA	NA
Cyanide	1.9E-16	2.0E-02	9.5E-15
Endrin	1.2E-13	3.0E-04	3.9E-10
Lead	2.4E-10	NA	NA
Manganese	1.2E-08	1.4E-01	8.8E-08
Mercury	5.9E-12	3.0E-04	2.0E-08
Molybdenum	3.7E-10	5.0E-03	7.5E-08
Nickel	8.2E-10	2.0E-02	4.1E-08
Selenium	1.2E-10	5.0E-03	2.4E-08
Silver	6.0E-09	5.0E-03	1.2E-06
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	4.0E-11	8.0E-05	5.0E-07
Thorium	NA	NA	NA
Uranium	1.6E-08	3.0E-03	5.3E-06
Vanadium	1.9E-11	7.0E-03	2.7E-09
Zinc	3.9E-08	3.0E-01	1.3E-07
	HQ Summation =		8.0E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	3.8E-13	3.4E-01	1.3E-13
Antimony	3.7E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.1E-11	7.7E+00	8.7E-11
Aroclor-1260	7.7E-12	7.7E+00	5.9E-11
Arsenic	1.3E-12	1.8E+00	2.3E-12
Barium	1.2E-10	NA	NA
Beryllium	2.1E-15	4.3E+00	9.0E-15
Boron	7.9E-10	NA	NA
Cadmium	1.7E-11	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	7.1E-11	NA	NA
Cobalt	7.3E-11	NA	NA
Copper	1.2E-10	NA	NA
Cyanide	1.6E-17	NA	NA
Endrin	1.0E-14	NA	NA
Lead	2.1E-11	NA	NA
Manganese	1.1E-09	NA	NA
Mercury	5.1E-13	NA	NA
Molybdenum	3.2E-11	NA	NA
Nickel	7.0E-11	NA	NA
Selenium	1.0E-11	NA	NA
Silver	5.1E-10	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	3.4E-12	NA	NA
Thorium	NA	NA	NA
Uranium	1.4E-09	NA	NA
Vanadium	1.6E-12	NA	NA
Zinc	3.4E-09	NA	NA
	ILCR Summation =		1.5E-10

Table I.IV-65
Summary of Intake and Risk Quantitation (Radionuclides)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.68 l/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Cs-137	3.55E-06	pCi/l	Ru-106	7.81E-32	pCi/l
Np-237	2.41E-05	pCi/l	Sr-90	1.78E-27	pCi/l
Pa-231	1.0E-07	pCi/l	Tc-99	1.04E-18	pCi/l
Pb-210	NA	pCi/l	Th-228	1.78E-09	pCi/l
Pu-238	3.2E-11	pCi/l	Th-230	1.35E-08	pCi/l
Pu-239	7.9E-12	pCi/l	Th-232	4.90E-09	pCi/l
Pu-240	2.9E-11	pCi/l	U-234	9.43E-01	pCi/l
Ra-226	1.4E-07	pCi/l	U-235	2.51E-02	pCi/l
Ra-228	2.5E-07	pCi/l	U-236	1.03E-02	pCi/l
Rn-222	NA	pCi/l	U-238	5.65E-01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	5.1E-03	2.8E-11	1.4E-13
Np-237	3.4E-02	2.2E-10	7.6E-12
Pa-231	1.5E-04	9.2E-11	1.4E-14
Pb-210	NA	6.6E-10	NA
Pu-238	4.5E-08	2.2E-10	9.9E-18
Pu-239	1.1E-08	2.3E-10	2.6E-18
Pu-240	4.1E-08	2.3E-10	9.5E-18
Ra-226	2.0E-04	1.2E-10	2.4E-14
Ra-228	3.5E-04	1.0E-10	3.5E-14
Rn-222	NA	1.7E-12	NA
Ru-106	1.1E-28	9.5E-12	1.1E-39
Sr-90	2.5E-24	3.6E-11	9.1E-35
Tc-99	1.5E-15	1.3E-12	1.9E-27
Th-228	2.5E-06	5.5E-11	1.4E-16
Th-230	1.9E-05	1.3E-11	2.5E-16
Th-232	7.0E-06	1.2E-11	8.4E-17
U-234	1.3E+03	1.6E-11	2.2E-08
U-235	3.6E+01	1.6E-11	5.7E-10
U-236	1.5E+01	1.5E-11	2.2E-10
U-238	8.1E+02	2.8E-11	2.3E-08
		ILCR Summation =	4.5E-08

Table I.IV-66
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
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	0.106 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 x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	5.3E-10	mg/kg
4,4-DDE	1.4E-10	mg/kg
Antimony	7.4E-08	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	4.7E-09	mg/kg
Aroclor-1260	2.6E-09	mg/kg
Arsenic	7.3E-08	mg/kg
Barium	1.2E-06	mg/kg
Beryllium	8.1E-09	mg/kg
Boron	1.6E-06	mg/kg
Cadmium	5.2E-08	mg/kg
Carbazole	1.0E-09	mg/kg
Chromium	1.7E-07	mg/kg
Cobalt	1.3E-07	mg/kg
Copper	2.8E-07	mg/kg

Compound	Concentration	Units
Cyanide	3.1E-09	mg/kg
Endrin	2.0E-11	mg/kg
Lead	2.9E-07	mg/kg
Manganese	1.0E-05	mg/kg
Mercury	3.8E-09	mg/kg
Molybdenum	8.1E-08	mg/kg
Nickel	2.4E-07	mg/kg
Selenium	8.9E-09	mg/kg
Silver	8.8E-08	mg/kg
Tetrachlordibenzo-p-dioxin	2.8E-15	mg/kg
Thallium	6.0E-09	mg/kg
Thorium	3.1E-07	mg/kg
Uranium	7.9E-06	mg/kg
Vanadium	2.9E-07	mg/kg
Zinc	9.8E-07	mg/kg

References

Table I.IV-66 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Ingestion of Vegetables and Fruits

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	1.8E-12	NA	NA
4,4-DDE	4.8E-13	NA	NA
Antimony	2.5E-10	4.0E-04	6.3E-07
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.6E-11	NA	NA
Aroclor-1260	8.9E-12	NA	NA
Arsenic	2.5E-10	3.0E-04	8.2E-07
Barium	4.0E-09	7.0E-02	5.7E-08
Beryllium	2.7E-11	5.0E-03	5.5E-09
Boron	5.5E-09	9.0E-02	6.1E-08
Cadmium	1.8E-10	1.0E-03	1.8E-07
Carbazole	3.4E-12	NA	NA
Chromium	5.6E-10	5.0E-03	1.1E-07
Cobalt	4.3E-10	6.0E-02	7.1E-09
Copper	9.4E-10	NA	NA
Cyanide	1.1E-11	2.0E-02	5.3E-10
Endrin	6.8E-14	3.0E-04	2.3E-10
Lead	9.7E-10	NA	NA
Manganese	3.5E-08	1.4E-01	2.5E-07
Mercury	1.3E-11	3.0E-04	4.3E-08
Molybdenum	2.7E-10	5.0E-03	5.5E-08
Nickel	8.3E-10	2.0E-02	4.1E-08
Selenium	3.0E-11	5.0E-03	6.0E-09
Silver	3.0E-10	5.0E-03	6.0E-08
Tetrachlordibenzo-p-dioxin	9.5E-18	NA	NA
Thallium	2.0E-11	8.0E-05	2.5E-07
Thorium	1.1E-09	NA	NA
Uranium	2.7E-08	3.0E-03	9.0E-06
Vanadium	9.7E-10	7.0E-03	1.4E-07
Zinc	3.3E-09	3.0E-01	1.1E-08
	HQ Summation =		1.2E-05

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	1.5E-13	NA	NA
4,4-DDE	4.1E-14	3.4E-01	1.4E-14
Antimony	2.2E-11	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.4E-12	7.7E+00	1.0E-11
Aroclor-1260	7.6E-13	7.7E+00	5.9E-12
Arsenic	2.1E-11	1.8E+00	3.8E-11
Barium	3.4E-10	NA	NA
Beryllium	2.4E-12	4.3E+00	1.0E-11
Boron	4.7E-10	NA	NA
Cadmium	1.5E-11	NA	NA
Carbazole	2.9E-13	2.0E-02	5.8E-15
Chromium	4.8E-11	NA	NA
Cobalt	3.7E-11	NA	NA
Copper	8.1E-11	NA	NA
Cyanide	9.0E-13	NA	NA
Endrin	5.8E-15	NA	NA
Lead	8.3E-11	NA	NA
Manganese	3.0E-09	NA	NA
Mercury	1.1E-12	NA	NA
Molybdenum	2.3E-11	NA	NA
Nickel	7.1E-11	NA	NA
Selenium	2.6E-12	NA	NA
Silver	2.6E-11	NA	NA
Tetrachlordibenzo-p-dioxin	8.1E-19	1.5E+05	1.2E-13
Thallium	1.7E-12	NA	NA
Thorium	9.1E-11	NA	NA
Uranium	2.3E-09	NA	NA
Vanadium	8.3E-11	NA	NA
Zinc	2.8E-10	NA	NA
	ILCR Summation =		6.5E-11

000612

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Table I.IV–67
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Future Land Use With Federal Ownership
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.106 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	

Cs-137	6.51E-06	pCi/kg	Ru-106	4.38E-17	pCi/kg
Np-237	2.65E-06	pCi/kg	Sr-90	4.09E-16	pCi/kg
Pa-231	2.7E-06	pCi/kg	Tc-99	2.25E-07	pCi/kg
Pb-210	1.1E-05	pCi/kg	Th-228	4.75E-06	pCi/kg
Pu-238	4.1E-06	pCi/kg	Th-230	3.51E-05	pCi/kg
Pu-239	1.0E-06	pCi/kg	Th-232	1.28E-05	pCi/kg
Pu-240	3.8E-06	pCi/kg	U-234	1.28E+02	pCi/kg
Ra-226	4.2E-06	pCi/kg	U-235	3.41E+00	pCi/kg
Ra-228	7.3E-06	pCi/kg	U-236	1.40E+00	pCi/kg
Rn-222	3.6E-01	pCi/kg	U-238	7.68E+01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	7.3E-04	2.8E-11	2.0E-14
Np-237	3.0E-04	2.2E-10	6.5E-14
Pa-231	3.0E-04	9.2E-11	2.8E-14
Pb-210	1.2E-03	6.6E-10	8.2E-13
Pu-238	4.6E-04	2.2E-10	1.0E-13
Pu-239	1.1E-04	2.3E-10	2.6E-14
Pu-240	4.2E-04	2.3E-10	9.6E-14
Ra-226	4.6E-04	1.2E-10	5.6E-14
Ra-228	8.1E-04	1.0E-10	8.1E-14
Rn-222	4.0E+01	1.7E-12	6.8E-11
Ru-106	4.9E-15	9.5E-12	4.6E-26
Sr-90	4.6E-14	3.6E-11	1.6E-24
Tc-99	2.5E-05	1.3E-12	3.3E-17
Th-228	5.3E-04	5.5E-11	2.9E-14
Th-230	3.9E-03	1.3E-11	5.1E-14
Th-232	1.4E-03	1.2E-11	1.7E-14
U-234	1.4E+04	1.6E-11	2.3E-07
U-235	3.8E+02	1.6E-11	6.1E-09
U-236	1.6E+02	1.5E-11	2.3E-09
U-238	8.6E+03	2.8E-11	2.4E-07
		ILCR Summation =	4.8E-07

FEMP-OU1&2CRARE-3-DRAFT
April 29, 1994

INTAKE AND RISK CALCULATIONS:
FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP SCENARIO

Table I.IV-68
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR_o	Inhalation rate of gases (outdoors)	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 x 365)	25550 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	2.0E-08	mg/m^3
4,4-DDE	1.3E-09	mg/m^3
Antimony	1.8E-06	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-07	mg/m^3
Aroclor-1260	1.1E-07	mg/m^3
Arsenic	1.8E-06	mg/m^3
Barium	1.9E-05	mg/m^3
Beryllium	1.7E-07	mg/m^3
Boron	5.8E-05	mg/m^3
Cadmium	6.1E-07	mg/m^3
Carbazole	4.3E-08	mg/m^3
Chromium	2.6E-06	mg/m^3
Cobalt	1.8E-06	mg/m^3
Copper	4.6E-06	mg/m^3

Compound	Concentration	Units
Cyanide	5.9E-08	mg/m^3
Endrin	1.8E-09	mg/m^3
Lead	4.7E-06	mg/m^3
Manganese	1.5E-04	mg/m^3
Mercury	1.3E-07	mg/m^3
Molybdenum	9.6E-07	mg/m^3
Nickel	3.3E-06	mg/m^3
Selenium	2.3E-07	mg/m^3
Silver	1.0E-06	mg/m^3
Tetrachlorodibenzo-p-dioxin	1.4E-13	mg/m^3
Thallium	1.1E-07	mg/m^3
Thorium	2.9E-05	mg/m^3
Uranium	4.9E-04	mg/m^3
Vanadium	4.5E-06	mg/m^3
Zinc	1.3E-05	mg/m^3

References

000615

Table I.IV-68 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	5.3E-09	NA	NA
4,4-DDE	3.6E-10	NA	NA
Antimony	5.0E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.2E-08	NA	NA
Aroclor-1260	2.9E-08	NA	NA
Arsenic	4.8E-07	NA	NA
Barium	5.2E-06	1.0E-04	5.2E-02
Beryllium	4.7E-08	NA	NA
Boron	1.6E-05	5.7E-03	2.8E-03
Cadmium	1.7E-07	NA	NA
Carbazole	1.2E-08	NA	NA
Chromium	7.0E-07	NA	NA
Cobalt	5.0E-07	3.0E-07	1.7E+00
Copper	1.3E-06	NA	NA
Cyanide	1.6E-08	NA	NA
Endrin	5.0E-10	NA	NA
Lead	1.3E-06	NA	NA
Manganese	4.1E-05	1.1E-04	3.8E-01
Mercury	3.5E-08	8.6E-05	4.0E-04
Molybdenum	2.6E-07	NA	NA
Nickel	9.0E-07	NA	NA
Selenium	6.3E-08	NA	NA
Silver	2.7E-07	NA	NA
Tetrachlorodibenzo-p-dioxin	3.9E-14	NA	NA
Thallium	3.0E-08	NA	NA
Thorium	7.8E-06	NA	NA
Uranium	1.4E-04	NA	NA
Vanadium	1.2E-06	NA	NA
Zinc	3.5E-06	NA	NA
	HQ Summation =		2.1E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	5.3E-09	NA	NA
4,4-DDE	3.6E-10	NA	NA
Antimony	5.0E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.2E-08	NA	NA
Aroclor-1260	2.9E-08	NA	NA
Arsenic	4.8E-07	1.5E+01	7.3E-06
Barium	5.2E-06	NA	NA
Beryllium	4.7E-08	8.4E+00	4.0E-07
Boron	1.6E-05	NA	NA
Cadmium	1.7E-07	6.1E+00	1.0E-06
Carbazole	1.2E-08	NA	NA
Chromium	7.0E-07	4.1E+01	2.9E-05
Cobalt	5.0E-07	NA	NA
Copper	1.3E-06	NA	NA
Cyanide	1.6E-08	NA	NA
Endrin	5.0E-10	NA	NA
Lead	1.3E-06	NA	NA
Manganese	4.1E-05	NA	NA
Mercury	3.5E-08	NA	NA
Molybdenum	2.6E-07	NA	NA
Nickel	9.0E-07	8.4E-01	7.6E-07
Selenium	6.3E-08	NA	NA
Silver	2.7E-07	NA	NA
Tetrachlorodibenzo-p-dioxin	3.9E-14	1.5E+05	5.9E-09
Thallium	3.0E-08	NA	NA
Thorium	7.8E-06	NA	NA
Uranium	1.4E-04	NA	NA
Vanadium	1.2E-06	NA	NA
Zinc	3.5E-06	NA	NA
	ILCR Summation =		3.8E-05

000616

Table I.IV–69
Summary of Intake and Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR_o	Inhalation rate of gases (outdoors)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
CA_o	Concentration of radionuclides in outdoor air	(see table below)

Cs-137	9.3E-05	pCi/m^3	Ru-106	4.4E-05	pCi/m^3
Np-237	2.6E-04	pCi/m^3	Sr-90	1.9E-04	pCi/m^3
Pa-231	3.0E-04	pCi/m^3	Tc-99	3.4E-03	pCi/m^3
Pb-210	5.4E-04	pCi/m^3	Th-228	9.9E-05	pCi/m^3
Pu-238	4.3E-04	pCi/m^3	Th-230	4.2E-04	pCi/m^3
Pu-239	7.2E-05	pCi/m^3	Th-232	2.5E-04	pCi/m^3
Pu-240	2.6E-04	pCi/m^3	U-234	1.7E-02	pCi/m^3
Ra-226	7.0E-05	pCi/m^3	U-235	3.8E-04	pCi/m^3
Ra-228	1.2E-04	pCi/m^3	U-236	1.2E-03	pCi/m^3
Rn-222	6.5E+00	pCi/m^3	U-238	5.5E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	4.6E+01	1.9E-11	8.7E-10
Np-237	1.3E+02	2.9E-08	3.8E-06
Pa-231	1.5E+02	3.6E-08	5.3E-06
Pb-210	2.6E+02	4.0E-09	1.1E-06
Pu-238	2.1E+02	3.9E-08	8.3E-06
Pu-239	3.5E+01	3.8E-08	1.3E-06
Pu-240	1.3E+02	3.8E-08	4.8E-06
Ra-226	3.4E+01	3.0E-09	1.0E-07
Ra-228	5.8E+01	6.9E-10	4.0E-08
Rn-222	3.2E+06	7.7E-12	2.5E-05
Ru-106	2.2E+01	4.4E-10	9.6E-09
Sr-90	9.2E+01	6.2E-11	5.7E-09
Tc-99	1.7E+03	8.3E-12	1.4E-08
Th-228	4.8E+01	7.8E-08	3.8E-06
Th-230	2.1E+02	2.9E-08	6.0E-06
Th-232	1.2E+02	2.8E-08	3.5E-06
U-234	8.5E+03	2.6E-08	2.2E-04
U-235	1.8E+02	2.5E-08	4.6E-06
U-236	6.1E+02	2.5E-08	1.5E-05
U-238	2.7E+03	5.2E-11	1.4E-07
		ILCR Summation =	3.0E-04

000648

Table I.IV-70
Summary of Intake Quantitation (Chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Incidental Ingestion of Soil

Intake 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	1.00E-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 x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/kg
4,4-DDE	NA	mg/kg
Antimony	2.8E+01	mg/kg
Aroclor-1221	NA	mg/kg
Aroclor-1248	NA	mg/kg
Aroclor-1254	NA	mg/kg
Aroclor-1260	NA	mg/kg
Arsenic	9.0E+01	mg/kg
Barium	4.1E+02	mg/kg
Beryllium	4.7E+00	mg/kg
Boron	6.6E+02	mg/kg
Cadmium	5.9E+00	mg/kg
Carbazole	NA	mg/kg
Chromium	4.5E+01	mg/kg
Cobalt	2.1E+01	mg/kg
Copper	7.4E+01	mg/kg

Compound	Concentration	Units
Cyanide	1.2E+00	mg/kg
Endrin	NA	mg/kg
Lead	1.2E+02	mg/kg
Manganese	2.2E+03	mg/kg
Mercury	1.1E+00	mg/kg
Molybdenum	1.3E+01	mg/kg
Nickel	4.0E+01	mg/kg
Selenium	5.9E+00	mg/kg
Silver	1.7E+01	mg/kg
Tetrachlorodibenzo-p-dioxin	5.6E-06	mg/kg
Thallium	2.7E+00	mg/kg
Thorium	NA	mg/kg
Uranium	NA	mg/kg
Vanadium	5.0E+01	mg/kg
Zinc	3.5E+02	mg/kg

References

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Table I.IV-70 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Incidental Ingestion of Soil

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	6.9E-05	4.0E-04	1.7E-01
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	2.2E-04	3.0E-04	7.4E-01
Barium	1.0E-03	7.0E-02	1.4E-02
Beryllium	1.2E-05	5.0E-03	2.3E-03
Boron	1.6E-03	9.0E-02	1.8E-02
Cadmium	1.5E-05	1.0E-03	1.5E-02
Carbazole	NA	NA	NA
Chromium	1.1E-04	5.0E-03	2.2E-02
Cobalt	5.1E-05	6.0E-02	8.5E-04
Copper	1.8E-04	NA	NA
Cyanide	3.0E-06	2.0E-02	1.5E-04
Endrin	NA	3.0E-04	NA
Lead	2.9E-04	NA	NA
Manganese	5.3E-03	1.4E-01	3.8E-02
Mercury	2.7E-06	3.0E-04	9.0E-03
Molybdenum	3.2E-05	5.0E-03	6.5E-03
Nickel	9.9E-05	2.0E-02	4.9E-03
Selenium	1.5E-05	5.0E-03	2.9E-03
Silver	4.2E-05	5.0E-03	8.5E-03
Tetrachlorodibenzo-p-dioxin	1.4E-11	NA	NA
Thallium	6.7E-06	8.0E-05	8.3E-02
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	NA
Vanadium	1.2E-04	7.0E-03	1.8E-02
Zinc	8.7E-04	3.0E-01	2.9E-03
	HQ Summation =		1.2E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	6.9E-05	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	2.2E-04	1.8E+00	4.0E-04
Barium	1.0E-03	NA	NA
Beryllium	1.2E-05	4.3E+00	5.0E-05
Boron	1.6E-03	NA	NA
Cadmium	1.5E-05	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	1.1E-04	NA	NA
Cobalt	5.1E-05	NA	NA
Copper	1.8E-04	NA	NA
Cyanide	3.0E-06	NA	NA
Endrin	NA	NA	NA
Lead	2.9E-04	NA	NA
Manganese	5.3E-03	NA	NA
Mercury	2.7E-06	NA	NA
Molybdenum	3.2E-05	NA	NA
Nickel	9.9E-05	NA	NA
Selenium	1.5E-05	NA	NA
Silver	4.2E-05	NA	NA
Tetrachlorodibenzo-p-dioxin	1.4E-11	1.5E+05	2.1E-06
Thallium	6.7E-06	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	1.2E-04	NA	NA
Zinc	8.7E-04	NA	NA
	ILCR Summation =		4.5E-04

Table I.IV–71
Summary of Intake and Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Incidental Ingestion of Soil

Intake 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		(see table below)

Cs–137	1.0E–03	pCi/mg	Ru–106	1.3E–03	pCi/mg
Np–237	5.0E–03	pCi/mg	Sr–90	6.1E–03	pCi/mg
Pa–231	1.4E–02	pCi/mg	Tc–99	3.2E–01	pCi/mg
Pb–210	2.0E–02	pCi/mg	Th–228	4.0E–04	pCi/mg
Pu–238	4.0E–02	pCi/mg	Th–230	5.0E–03	pCi/mg
Pu–239	5.3E–03	pCi/mg	Th–232	5.0E–03	pCi/mg
Pu–240	1.9E–02	pCi/mg	U–234	7.5E–01	pCi/mg
Ra–226	2.9E–03	pCi/mg	U–235	9.0E–03	pCi/mg
Ra–228	2.0E–03	pCi/mg	U–236	9.0E–03	pCi/mg
Rn–222	NA	pCi/mg	U–238	6.0E–02	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs–137	4.4E+03	2.8E–11	1.2E–07
Np–237	2.2E+04	2.2E–10	4.9E–06
Pa–231	6.0E+04	9.2E–11	5.6E–06
Pb–210	8.6E+04	6.6E–10	5.7E–05
Pu–238	1.8E+05	2.2E–10	3.9E–05
Pu–239	2.3E+04	2.3E–10	5.4E–06
Pu–240	8.5E+04	2.3E–10	2.0E–05
Ra–226	1.3E+04	1.2E–10	1.5E–06
Ra–228	8.8E+03	1.0E–10	8.8E–07
Rn–222	NA	1.7E–12	NA
Ru–106	5.7E+03	9.5E–12	5.4E–08
Sr–90	2.7E+04	3.6E–11	9.6E–07
Tc–99	1.4E+06	1.3E–12	1.8E–06
Th–228	1.8E+03	5.5E–11	9.7E–08
Th–230	2.2E+04	1.3E–11	2.9E–07
Th–232	2.2E+04	1.2E–11	2.6E–07
U–234	3.3E+06	1.6E–11	5.3E–05
U–235	4.0E+04	1.6E–11	6.4E–07
U–236	4.0E+04	1.5E–11	6.0E–07
U–238	2.6E+05	2.8E–11	7.4E–06
		ILCR Summation =	2.0E–04

Table I.IV-72
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
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
2-Methylnaphthalene	NA	mg/l
4,4-DDE	NA	mg/l
Antimony	1.2E-03	mg/l
Aroclor-1221	2.3E-24	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	NA	mg/l
Aroclor-1260	NA	mg/l
Arsenic	NA	mg/l
Barium	NA	mg/l
Beryllium	NA	mg/l
Boron	NA	mg/l
Cadmium	2.9E-20	mg/l
Carbazole	NA	mg/l
Chromium	NA	mg/l
Cobalt	NA	mg/l
Copper	NA	mg/l

Compound	Concentration	Units
Cyanide	NA	mg/l
Endrin	NA	mg/l
Lead	NA	mg/l
Manganese	NA	mg/l
Mercury	NA	mg/l
Molybdenum	NA	mg/l
Nickel	NA	mg/l
Selenium	NA	mg/l
Silver	NA	mg/l
Tetrachlorodibenzo-p-dioxin	NA	mg/l
Thallium	NA	mg/l
Thorium	NA	mg/l
Uranium	NA	mg/l
Vanadium	NA	mg/l
Zinc	NA	mg/l

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Table I.IV-72
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	3.4E-05	4.0E-04	8.5E-02
Aroclor-1221	6.3E-26	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	NA	3.0E-04	0.0E+00
Barium	NA	7.0E-02	0.0E+00
Beryllium	NA	5.0E-03	0.0E+00
Boron	NA	9.0E-02	0.0E+00
Cadmium	7.9E-22	1.0E-03	7.9E-19
Carbazole	NA	NA	NA
Chromium	NA	5.0E-03	0.0E+00
Cobalt	NA	6.0E-02	0.0E+00
Copper	NA	NA	NA
Cyanide	NA	2.0E-02	0.0E+00
Endrin	NA	3.0E-04	0.0E+00
Lead	NA	NA	NA
Manganese	NA	1.4E-01	0.0E+00
Mercury	NA	3.0E-04	0.0E+00
Molybdenum	NA	5.0E-03	0.0E+00
Nickel	NA	2.0E-02	0.0E+00
Selenium	NA	5.0E-03	0.0E+00
Silver	NA	5.0E-03	0.0E+00
Tetrachlorodibenzo-p-dioxin	NA	NA	NA
Thallium	NA	8.0E-05	0.0E+00
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	0.0E+00
Vanadium	NA	7.0E-03	0.0E+00
Zinc	NA	3.0E-01	0.0E+00
	HQ Summation =		8.5E-02

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	3.4E-05	NA	0.0E+00
Aroclor-1221	6.3E-26	7.7E+00	4.8E-25
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	NA	1.8E+00	NA
Barium	NA	NA	NA
Beryllium	NA	4.3E+00	NA
Boron	NA	NA	NA
Cadmium	7.9E-22	NA	0.0E+00
Carbazole	NA	2.0E-02	NA
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	NA	NA	NA
Cyanide	NA	NA	NA
Endrin	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Molybdenum	NA	NA	NA
Nickel	NA	NA	NA
Selenium	NA	NA	NA
Silver	NA	NA	NA
Tetrachlorodibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	NA	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	NA	NA	NA
	ILCR Summation =		4.8E-25

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Table I.IV–73
Summary of Intake and Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
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)

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	5.7E-01	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	5.2E+03	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	1.0E+02	pCi/l
Ra-226	NA	pCi/l	U-235	2.7E+00	pCi/l
Ra-228	NA	pCi/l	U-236	1.1E+00	pCi/l
Rn-222	NA	pCi/l	U-238	6.0E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	2.8E+04	2.2E-10	6.1E-06
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	2.6E+08	1.3E-12	3.3E-04
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	4.9E+06	1.6E-11	7.9E-05
U-235	1.3E+05	1.6E-11	2.1E-06
U-236	5.4E+04	1.5E-11	8.2E-07
U-238	2.9E+06	2.8E-11	8.2E-05
		ILCR Summation =	5.0E-04

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Table I.IV-74
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Dermal Contact with Soil

Intake 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	Chemical 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 x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	ABS	Concentrati	Units
2-Methylnaphthalene	3.0E-01	NA	mg/kg
4,4-DDE	3.0E-01	NA	mg/kg
Antimony	1.0E-02	2.8E+01	mg/kg
Aroclor-1221	6.0E-02	NA	mg/kg
Aroclor-1248	6.0E-02	NA	mg/kg
Aroclor-1254	6.0E-02	NA	mg/kg
Aroclor-1260	6.0E-02	NA	mg/kg
Arsenic	1.0E-03	9.0E+01	mg/kg
Barium	1.0E-02	4.1E+02	mg/kg
Beryllium	1.0E-02	4.7E+00	mg/kg
Boron	1.0E-02	6.6E+02	mg/kg
Cadmium	1.0E-02	5.9E+00	mg/kg
Carbazole	3.0E-01	NA	mg/kg
Chromium	1.0E-02	4.5E+01	mg/kg
Cobalt	1.0E-02	2.1E+01	mg/kg
Copper	1.0E-03	7.4E+01	mg/kg

Compound	ABS	Concentration	Units
Cyanide	1.0E-02	1.2E+00	mg/kg
Endrin	3.0E-01	NA	mg/kg
Lead	1.0E-02	1.2E+02	mg/kg
Manganese	1.0E-02	2.2E+03	mg/kg
Mercury	5.0E-02	1.1E+00	mg/kg
Molybdenum	1.0E-02	1.3E+01	mg/kg
Nickel	5.0E-04	4.0E+01	mg/kg
Selenium	1.0E-02	5.9E+00	mg/kg
Silver	1.0E-02	1.7E+01	mg/kg
Tetrachlorodibenzo-p-dioxin	3.0E-02	5.6E-06	mg/kg
Thallium	1.0E-02	2.7E+00	mg/kg
Thorium	1.0E-02	NA	mg/kg
Uranium	1.0E-02	NA	mg/kg
Vanadium	1.0E-03	5.0E+01	mg/kg
Zinc	1.0E-02	3.5E+02	mg/kg

References

Table I.IV-74 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Dermal Contact with Soil

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	2.2E-05	6.0E-05	3.7E-01
Aroclor-1221	NA	5.3E-05	NA
Aroclor-1248	NA	5.3E-05	NA
Aroclor-1254	NA	5.3E-05	NA
Aroclor-1260	NA	5.3E-05	NA
Arsenic	7.1E-06	2.9E-04	2.5E-02
Barium	3.2E-04	6.4E-02	5.1E-03
Beryllium	3.7E-06	5.0E-05	7.4E-02
Boron	5.2E-04	4.5E-03	1.1E-01
Cadmium	4.7E-06	5.0E-05	9.3E-02
Carbazole	NA	NA	NA
Chromium	3.5E-05	2.3E-03	1.6E-02
Cobalt	1.6E-05	2.7E-02	6.0E-04
Copper	5.8E-06	2.2E-02	2.6E-04
Cyanide	9.5E-07	NA	NA
Endrin	NA	2.7E-04	NA
Lead	9.2E-05	NA	NA
Manganese	1.7E-03	4.2E-03	4.0E-01
Mercury	4.3E-06	4.5E-05	9.6E-02
Molybdenum	1.0E-05	1.9E-03	5.4E-03
Nickel	1.6E-06	2.0E-03	7.9E-04
Selenium	4.6E-06	4.0E-03	1.2E-03
Silver	1.4E-05	NA	NA
Tetrachlorodibenzo-p-dioxin	1.3E-11	NA	NA
Thallium	2.1E-06	6.0E-05	3.5E-02
Thorium	NA	NA	NA
Uranium	NA	1.5E-04	NA
Vanadium	4.0E-06	3.5E-04	1.1E-02
Zinc	2.8E-04	7.5E-02	3.7E-03
	HQ Summation =		1.3E+00

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.8E-01	NA
Antimony	2.2E-05	NA	NA
Aroclor-1221	NA	1.0E+01	NA
Aroclor-1248	NA	1.0E+01	NA
Aroclor-1254	NA	1.0E+01	NA
Aroclor-1260	NA	1.0E+01	NA
Arsenic	7.1E-06	1.9E+00	1.3E-05
Barium	3.2E-04	NA	NA
Beryllium	3.7E-06	4.3E+02	1.6E-03
Boron	5.2E-04	NA	NA
Cadmium	4.7E-06	NA	NA
Carbazole	NA	2.2E-02	NA
Chromium	3.5E-05	NA	NA
Cobalt	1.6E-05	NA	NA
Copper	5.8E-06	NA	NA
Cyanide	9.5E-07	NA	NA
Endrin	NA	NA	NA
Lead	9.2E-05	NA	NA
Manganese	1.7E-03	NA	NA
Mercury	4.3E-06	NA	NA
Molybdenum	1.0E-05	NA	NA
Nickel	1.6E-06	NA	NA
Selenium	4.6E-06	NA	NA
Silver	1.4E-05	NA	NA
Tetrachlorodibenzo-p-dioxin	1.3E-11	3.0E+05	4.0E-06
Thallium	2.1E-06	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	4.0E-06	NA	NA
Zinc	2.8E-04	NA	NA
	ILCR Summation =		1.6E-03

Table I.IV–75
Summary of Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via External Radiation

Exposure Equation = $[CR \times EF \times ED_n \times ET_i \times (1-SH_i)] + [CR \times EF \times ED_n \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.95 (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	0 (unitless)
CR	Radionuclide specific concentrations	(see table below)

Cs-137	1.0E+00 pCi/g	Ru-106	1.3E+00 pCi/g
Np-237	5.0E+00 pCi/g	Sr-90	6.1E+00 pCi/g
Pa-231	1.4E+01 pCi/g	Tc-99	3.2E+02 pCi/g
Pb-210	2.0E+01 pCi/g	Th-228	4.0E-01 pCi/g
Pu-238	4.0E+01 pCi/g	Th-230	5.0E+00 pCi/g
Pu-239	5.3E+00 pCi/g	Th-232	5.0E+00 pCi/g
Pu-240	1.9E+01 pCi/g	U-234	7.5E+02 pCi/g
Ra-226	2.9E+00 pCi/g	U-235	9.0E+00 pCi/g
Ra-228	2.0E+00 pCi/g	U-236	9.0E+00 pCi/g
Rn-222	NA pCi/g	U-238	6.0E+01 pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs-137	4.1E+01	2.0E-06	8.2E-05
Np-237	2.1E+02	4.3E-07	8.9E-05
Pa-231	5.6E+02	2.6E-08	1.5E-05
Pb-210	8.1E+02	1.6E-10	1.3E-07
Pu-238	1.6E+03	2.8E-11	4.6E-08
Pu-239	2.2E+02	1.7E-11	3.7E-09
Pu-240	8.0E+02	2.7E-11	2.1E-08
Ra-226	1.2E+02	6.0E-06	7.2E-04
Ra-228	8.2E+01	2.9E-06	2.4E-04
Rn-222	NA	5.9E-06	NA
Ru-106	5.4E+01	NA	NA
Sr-90	2.5E+02	NA	NA
Tc-99	1.3E+04	6.0E-13	7.9E-09
Th-228	1.6E+01	5.6E-06	9.2E-05
Th-230	2.1E+02	5.4E-11	1.1E-08
Th-232	2.1E+02	2.6E-11	5.4E-09
U-234	3.1E+04	3.0E-11	9.3E-07
U-235	3.7E+02	2.4E-07	8.9E-05
U-236	3.7E+02	2.4E-11	8.9E-09
U-238	2.5E+03	3.6E-08	8.9E-05
		ILCR Summation =	1.4E-03

Table I.IV-76
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
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	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (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
2-Methylnaphthalene	0.0E+00	mg/kg
4,4-DDE	5.9E-04	mg/kg
Antimony	1.1E-02	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	7.5E-03	mg/kg
Aroclor-1260	9.6E-03	mg/kg
Arsenic	2.5E-02	mg/kg
Barium	1.2E-01	mg/kg
Beryllium	7.6E-04	mg/kg
Boron	1.8E+01	mg/kg
Cadmium	5.4E-02	mg/kg
Carbazole	0.0E+00	mg/kg
Chromium	7.9E-02	mg/kg
Cobalt	3.6E-01	mg/kg
Copper	4.1E+00	mg/kg
Cyanide	2.5E-07	mg/kg
Endrin	3.1E-06	mg/kg
Lead	1.9E-02	mg/kg
Manganese	5.1E+00	mg/kg
Mercury	2.4E+00	mg/kg
Molybdenum	1.4E-01	mg/kg
Nickel	4.7E-01	mg/kg
Selenium	1.7E-02	mg/kg
Silver	3.7E-01	mg/kg
Tetrachlorodibenzo-p-dioxin	0.0E+00	mg/kg
Thallium	1.6E-02	mg/kg
Thorium	0.0E+00	mg/kg
Uranium	1.2E-07	mg/kg
Vanadium	5.0E-02	mg/kg
Zinc	4.8E+02	mg/kg

References

Table I.IV-76 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	6.1E-07	NA	NA
Antimony	1.1E-05	4.0E-04	2.8E-02
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	7.8E-06	NA	NA
Aroclor-1260	9.9E-06	NA	NA
Arsenic	2.6E-05	3.0E-04	8.7E-02
Barium	1.2E-04	7.0E-02	1.7E-03
Beryllium	7.8E-07	5.0E-03	1.6E-04
Boron	1.8E-02	9.0E-02	2.1E-01
Cadmium	5.5E-05	1.0E-03	5.5E-02
Carbazole	NA	NA	NA
Chromium	8.1E-05	5.0E-03	1.6E-02
Cobalt	3.7E-04	6.0E-02	6.2E-03
Copper	4.3E-03	NA	NA
Cyanide	2.6E-10	2.0E-02	1.3E-08
Endrin	3.2E-09	3.0E-04	1.1E-05
Lead	2.0E-05	NA	NA
Manganese	5.2E-03	1.4E-01	3.7E-02
Mercury	2.5E-03	3.0E-04	8.3E+00
Molybdenum	1.4E-04	5.0E-03	2.8E-02
Nickel	4.9E-04	2.0E-02	2.4E-02
Selenium	1.7E-05	5.0E-03	3.4E-03
Silver	3.8E-04	5.0E-03	7.6E-02
Tetrachlorodibenzo-p-dioxin	NA	NA	NA
Thallium	1.6E-05	8.0E-05	2.0E-01
Thorium	NA	NA	NA
Uranium	1.3E-10	3.0E-03	4.2E-08
Vanadium	5.2E-05	7.0E-03	7.4E-03
Zinc	5.0E-01	3.0E-01	1.7E+00
	HQ Summation =		1.1E+01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	6.1E-07	3.4E-01	2.1E-07
Antimony	1.1E-05	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	7.8E-06	7.7E+00	6.0E-05
Aroclor-1260	9.9E-06	7.7E+00	7.6E-05
Arsenic	2.6E-05	1.8E+00	4.7E-05
Barium	1.2E-04	NA	NA
Beryllium	7.8E-07	4.3E+00	3.3E-06
Boron	1.8E-02	NA	NA
Cadmium	5.5E-05	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	8.1E-05	NA	NA
Cobalt	3.7E-04	NA	NA
Copper	4.3E-03	NA	NA
Cyanide	2.6E-10	NA	NA
Endrin	3.2E-09	NA	NA
Lead	2.0E-05	NA	NA
Manganese	5.2E-03	NA	NA
Mercury	2.5E-03	NA	NA
Molybdenum	1.4E-04	NA	NA
Nickel	4.9E-04	NA	NA
Selenium	1.7E-05	NA	NA
Silver	3.8E-04	NA	NA
Tetrachlorodibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	1.6E-05	NA	NA
Thorium	NA	NA	NA
Uranium	1.3E-10	NA	NA
Vanadium	5.2E-05	NA	NA
Zinc	5.0E-01	NA	NA
	ILCR Summation =		1.9E-04

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Table I.IV-77
Summary of Intake and Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs-137	5.26E+01	pCi/kg	Ru-106	0.00E+00	pCi/kg
Np-237	6.16E-03	pCi/kg	Sr-90	1.25E-01	pCi/kg
Pa-231	1.7E-05	pCi/kg	Tc-99	7.95E+00	pCi/kg
Pb-210	0.0E+00	pCi/kg	Th-228	1.21E-03	pCi/kg
Pu-238	2.4E-05	pCi/kg	Th-230	3.29E-04	pCi/kg
Pu-239	3.3E-06	pCi/kg	Th-232	6.93E-03	pCi/kg
Pu-240	1.2E-05	pCi/kg	U-234	4.82E+00	pCi/kg
Ra-226	9.6E-02	pCi/kg	U-235	2.00E-01	pCi/kg
Ra-228	1.7E-01	pCi/kg	U-236	1.28E+00	pCi/kg
Rn-222	0.0E+00	pCi/kg	U-238	3.15E+00	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	9.7E+04	2.8E-11	2.7E-06
Np-237	1.1E+01	2.2E-10	2.5E-09
Pa-231	3.1E-02	9.2E-11	2.8E-12
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	4.4E-02	2.2E-10	9.6E-12
Pu-239	6.0E-03	2.3E-10	1.4E-12
Pu-240	2.2E-02	2.3E-10	5.0E-12
Ra-226	1.8E+02	1.2E-10	2.1E-08
Ra-228	3.1E+02	1.0E-10	3.1E-08
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	0.0E+00	9.5E-12	NA
Sr-90	2.3E+02	3.6E-11	8.3E-09
Tc-99	1.5E+04	1.3E-12	1.9E-08
Th-228	2.2E+00	5.5E-11	1.2E-10
Th-230	6.1E-01	1.3E-11	7.9E-12
Th-232	1.3E+01	1.2E-11	1.5E-10
U-234	8.9E+03	1.6E-11	1.4E-07
U-235	3.7E+02	1.6E-11	5.9E-09
U-236	2.4E+03	1.5E-11	3.5E-08
U-238	5.8E+03	2.8E-11	1.6E-07
		ILCR Summation =	3.1E-06

Table I.IV-78
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
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	0.3 l/day
FI	Fraction ingested from contaminated source	1 (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
2-Methylnaphthalene	0.0E+00	mg/l
4,4-DDE	1.1E-04	mg/l
Antimony	1.1E-03	mg/l
Aroclor-1221	0.0E+00	mg/l
Aroclor-1248	0.0E+00	mg/l
Aroclor-1254	2.4E-03	mg/l
Aroclor-1260	3.0E-03	mg/l
Arsenic	7.6E-04	mg/l
Barium	2.7E-01	mg/l
Beryllium	6.8E-07	mg/l
Boron	3.4E+01	mg/l
Cadmium	9.7E-02	mg/l
Carbazole	0.0E+00	mg/l
Chromium	2.2E-02	mg/l
Cobalt	3.6E-02	mg/l
Copper	6.2E-01	mg/l

Compound	Concentration	Units
Cyanide	8.1E-08	mg/l
Endrin	4.5E-07	mg/l
Lead	1.6E-02	mg/l
Manganese	4.4E+00	mg/l
Mercury	4.4E-03	mg/l
Molybdenum	3.4E-02	mg/l
Nickel	7.9E-02	mg/l
Selenium	4.4E-03	mg/l
Silver	2.5E+00	mg/l
Tetrachlorodibenzo-p-dioxin	0.0E+00	mg/l
Thallium	7.8E-04	mg/l
Thorium	0.0E+00	mg/l
Uranium	3.7E-07	mg/l
Vanadium	4.0E-04	mg/l
Zinc	4.8E+01	mg/l

References

Table I.IV-78 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Ingestion of Dairy Products

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.7E-07	NA	NA
Antimony	4.4E-06	4.0E-04	1.1E-02
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.8E-06	NA	NA
Aroclor-1260	1.2E-05	NA	NA
Arsenic	3.1E-06	3.0E-04	1.0E-02
Barium	1.1E-03	7.0E-02	1.6E-02
Beryllium	2.8E-09	5.0E-03	5.6E-07
Boron	1.4E-01	9.0E-02	1.5E+00
Cadmium	4.0E-04	1.0E-03	4.0E-01
Carbazole	NA	NA	NA
Chromium	8.8E-05	5.0E-03	1.8E-02
Cobalt	1.5E-04	6.0E-02	2.5E-03
Copper	2.6E-03	NA	NA
Cyanide	3.3E-10	2.0E-02	1.7E-08
Endrin	1.8E-09	3.0E-04	6.2E-06
Lead	6.6E-05	NA	NA
Manganese	1.8E-02	1.4E-01	1.3E-01
Mercury	1.8E-05	3.0E-04	6.0E-02
Molybdenum	1.4E-04	5.0E-03	2.8E-02
Nickel	3.3E-04	2.0E-02	1.6E-02
Selenium	1.8E-05	5.0E-03	3.6E-03
Silver	1.0E-02	5.0E-03	2.0E+00
Tetrachlorodibenzo-p-dioxin	NA	NA	NA
Thallium	3.2E-06	8.0E-05	4.0E-02
Thorium	NA	NA	NA
Uranium	1.5E-09	3.0E-03	5.0E-07
Vanadium	1.7E-06	7.0E-03	2.4E-04
Zinc	2.0E-01	3.0E-01	6.6E-01
	HQ Summation =		5.0E+00

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.7E-07	3.4E-01	1.6E-07
Antimony	4.4E-06	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	9.8E-06	7.7E+00	7.5E-05
Aroclor-1260	1.2E-05	7.7E+00	9.6E-05
Arsenic	3.1E-06	1.8E+00	5.6E-06
Barium	1.1E-03	NA	NA
Beryllium	2.8E-09	4.3E+00	1.2E-08
Boron	1.4E-01	NA	NA
Cadmium	4.0E-04	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	8.8E-05	NA	NA
Cobalt	1.5E-04	NA	NA
Copper	2.6E-03	NA	NA
Cyanide	3.3E-10	NA	NA
Endrin	1.8E-09	NA	NA
Lead	6.6E-05	NA	NA
Manganese	1.8E-02	NA	NA
Mercury	1.8E-05	NA	NA
Molybdenum	1.4E-04	NA	NA
Nickel	3.3E-04	NA	NA
Selenium	1.8E-05	NA	NA
Silver	1.0E-02	NA	NA
Tetrachlorodibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	3.2E-06	NA	NA
Thorium	NA	NA	NA
Uranium	1.5E-09	NA	NA
Vanadium	1.7E-06	NA	NA
Zinc	2.0E-01	NA	NA
	ILCR Summation =		1.8E-04

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Table I.IV–79
Summary of Intake and Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.3 l/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs-137	1.84E+01	pCi/l	Ru-106	1.79E-25	pCi/l
Np-237	5.88E-04	pCi/l	Sr-90	2.23E-19	pCi/l
Pa-231	1.0E-07	pCi/l	Tc-99	1.72E-17	pCi/l
Pb-210	0.0E+00	pCi/l	Th-228	9.65E-04	pCi/l
Pu-238	4.7E-06	pCi/l	Th-230	2.74E-04	pCi/l
Pu-239	6.5E-07	pCi/l	Th-232	5.87E-03	pCi/l
Pu-240	2.4E-06	pCi/l	U-234	1.51E+01	pCi/l
Ra-226	2.1E-01	pCi/l	U-235	6.15E-01	pCi/l
Ra-228	3.8E-01	pCi/l	U-236	3.85E+00	pCi/l
Rn-222	0.0E+00	pCi/l	U-238	9.82E+00	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.4E+05	2.8E-11	3.8E-06
Np-237	4.3E+00	2.2E-10	9.5E-10
Pa-231	7.6E-04	9.2E-11	7.0E-14
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	3.5E-02	2.2E-10	7.7E-12
Pu-239	4.8E-03	2.3E-10	1.1E-12
Pu-240	1.7E-02	2.3E-10	4.0E-12
Ra-226	1.6E+03	1.2E-10	1.9E-07
Ra-228	2.8E+03	1.0E-10	2.8E-07
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	1.3E-21	9.5E-12	1.2E-32
Sr-90	1.6E-15	3.6E-11	5.9E-26
Tc-99	1.3E-13	1.3E-12	1.6E-25
Th-228	7.1E+00	5.5E-11	3.9E-10
Th-230	2.0E+00	1.3E-11	2.6E-11
Th-232	4.3E+01	1.2E-11	5.2E-10
U-234	1.1E+05	1.6E-11	1.8E-06
U-235	4.5E+03	1.6E-11	7.2E-08
U-236	2.8E+04	1.5E-11	4.2E-07
U-238	7.2E+04	2.8E-11	2.0E-06
		ILCR Summation =	8.5E-06

Table I.IV-80
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
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
2-Methylnaphthalene	5.3E-10	mg/kg	Cyanide	3.1E-09	mg/kg
4,4-DDE	3.9E-04	mg/kg	Endrin	1.3E-06	mg/kg
Antimony	6.8E-02	mg/kg	Lead	9.0E-02	mg/kg
Aroclor-1221	0.0E+00	mg/kg	Manganese	2.1E+01	mg/kg
Aroclor-1248	0.0E+00	mg/kg	Mercury	1.8E-02	mg/kg
Aroclor-1254	2.4E-03	mg/kg	Molybdenum	1.7E+00	mg/kg
Aroclor-1260	1.4E-03	mg/kg	Nickel	5.8E-01	mg/kg
Arsenic	1.3E-02	mg/kg	Selenium	6.8E-03	mg/kg
Barium	6.2E-01	mg/kg	Silver	2.6E-01	mg/kg
Beryllium	3.2E-03	mg/kg	Tetrachlorodibenzo-p-dioxin	2.8E-15	mg/kg
Boron	9.6E+01	mg/kg	Thallium	9.5E-05	mg/kg
Cadmium	2.2E-01	mg/kg	Thorium	3.1E-07	mg/kg
Carbazole	1.0E-09	mg/kg	Uranium	7.9E-06	mg/kg
Chromium	3.2E-02	mg/kg	Vanadium	3.3E-02	mg/kg
Cobalt	3.6E-02	mg/kg	Zinc	2.5E+01	mg/kg
Copper	2.2E+00	mg/kg			

References

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Table 1.IV-80 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	3.2E-07	NA	NA
Antimony	5.7E-05	4.0E-04	1.4E-01
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.0E-06	NA	NA
Aroclor-1260	1.2E-06	NA	NA
Arsenic	1.1E-05	3.0E-04	3.6E-02
Barium	5.2E-04	7.0E-02	7.4E-03
Beryllium	2.7E-06	5.0E-03	5.4E-04
Boron	8.0E-02	9.0E-02	8.9E-01
Cadmium	1.9E-04	1.0E-03	1.9E-01
Carbazole	8.3E-13	NA	NA
Chromium	2.6E-05	5.0E-03	5.3E-03
Cobalt	3.0E-05	6.0E-02	5.1E-04
Copper	1.8E-03	NA	NA
Cyanide	2.6E-12	2.0E-02	1.3E-10
Endrin	1.1E-09	3.0E-04	3.7E-06
Lead	7.6E-05	NA	NA
Manganese	1.7E-02	1.4E-01	1.2E-01
Mercury	1.5E-05	3.0E-04	5.1E-02
Molybdenum	1.4E-03	5.0E-03	2.8E-01
Nickel	4.9E-04	2.0E-02	2.4E-02
Selenium	5.6E-06	5.0E-03	1.1E-03
Silver	2.2E-04	5.0E-03	4.3E-02
Tetrachlorodibenzo-p-dioxin	2.3E-18	NA	NA
Thallium	8.0E-08	8.0E-05	1.0E-03
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	3.0E-03	2.2E-06
Vanadium	2.8E-05	7.0E-03	4.0E-03
Zinc	2.1E-02	3.0E-01	6.9E-02
	HQ Summation =		1.9E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	3.2E-07	3.4E-01	1.1E-07
Antimony	5.7E-05	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	2.0E-06	7.7E+00	1.5E-05
Aroclor-1260	1.2E-06	7.7E+00	8.9E-06
Arsenic	1.1E-05	1.8E+00	2.0E-05
Barium	5.2E-04	NA	NA
Beryllium	2.7E-06	4.3E+00	1.2E-05
Boron	8.0E-02	NA	NA
Cadmium	1.9E-04	NA	NA
Carbazole	8.3E-13	2.0E-02	1.7E-14
Chromium	2.6E-05	NA	NA
Cobalt	3.0E-05	NA	NA
Copper	1.8E-03	NA	NA
Cyanide	2.6E-12	NA	NA
Endrin	1.1E-09	NA	NA
Lead	7.6E-05	NA	NA
Manganese	1.7E-02	NA	NA
Mercury	1.5E-05	NA	NA
Molybdenum	1.4E-03	NA	NA
Nickel	4.9E-04	NA	NA
Selenium	5.6E-06	NA	NA
Silver	2.2E-04	NA	NA
Tetrachlorodibenzo-p-dioxin	2.3E-18	1.5E+05	3.5E-13
Thallium	8.0E-08	NA	NA
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	NA	NA
Vanadium	2.8E-05	NA	NA
Zinc	2.1E-02	NA	NA
	ILCR Summation =		5.6E-05

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Table I.IV-81
Summary of Intake and Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Adult (GMA) Future Land Use Without Federal Ownership
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	

Cs-137	7.49E+00	pCi/kg	Ru-106	4.40E-11	pCi/kg
Np-237	3.58E-01	pCi/kg	Sr-90	3.36E-09	pCi/kg
Pa-231	2.7E-06	pCi/kg	Tc-99	1.01E-06	pCi/kg
Pb-210	4.0E+00	pCi/kg	Th-228	1.42E-02	pCi/kg
Pu-238	1.8E-03	pCi/kg	Th-230	2.19E-03	pCi/kg
Pu-239	2.4E-04	pCi/kg	Th-232	2.17E-02	pCi/kg
Pu-240	8.8E-04	pCi/kg	U-234	5.29E+02	pCi/kg
Ra-226	2.5E-01	pCi/kg	U-235	1.47E+01	pCi/kg
Ra-228	4.4E-01	pCi/kg	U-236	1.72E+01	pCi/kg
Rn-222	3.6E-01	pCi/kg	U-238	3.17E+02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.1E+04	2.8E-11	3.1E-07
Np-237	5.3E+02	2.2E-10	1.2E-07
Pa-231	4.0E-03	9.2E-11	3.7E-13
Pb-210	6.0E+03	6.6E-10	4.0E-06
Pu-238	2.6E+00	2.2E-10	5.8E-10
Pu-239	3.6E-01	2.3E-10	8.3E-11
Pu-240	1.3E+00	2.3E-10	3.0E-10
Ra-226	3.7E+02	1.2E-10	4.5E-08
Ra-228	6.6E+02	1.0E-10	6.6E-08
Rn-222	5.4E+02	1.7E-12	9.2E-10
Ru-106	6.6E-08	9.5E-12	6.3E-19
Sr-90	5.0E-06	3.6E-11	1.8E-16
Tc-99	1.5E-03	1.3E-12	2.0E-15
Th-228	2.1E+01	5.5E-11	1.2E-09
Th-230	3.3E+00	1.3E-11	4.3E-11
Th-232	3.2E+01	1.2E-11	3.9E-10
U-234	7.9E+05	1.6E-11	1.3E-05
U-235	2.2E+04	1.6E-11	3.5E-07
U-236	2.6E+04	1.5E-11	3.8E-07
U-238	4.7E+05	2.8E-11	1.3E-05
		ILCR Summation =	3.1E-05

Table I.IV-82
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR_o	Inhalation rate of gases (outdoors)	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 x 365)	25550 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	2.0E-08	mg/m^3
4,4-DDE	1.3E-09	mg/m^3
Antimony	1.8E-06	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-07	mg/m^3
Aroclor-1260	1.1E-07	mg/m^3
Arsenic	1.8E-06	mg/m^3
Barium	1.9E-05	mg/m^3
Beryllium	1.7E-07	mg/m^3
Boron	5.8E-05	mg/m^3
Cadmium	6.1E-07	mg/m^3
Carbazole	4.3E-08	mg/m^3
Chromium	2.6E-06	mg/m^3
Cobalt	1.8E-06	mg/m^3
Copper	4.6E-06	mg/m^3

Compound	Concentration	Units
Cyanide	5.9E-08	mg/m^3
Endrin	1.8E-09	mg/m^3
Lead	4.7E-06	mg/m^3
Manganese	1.5E-04	mg/m^3
Mercury	1.3E-07	mg/m^3
Molybdenum	9.6E-07	mg/m^3
Nickel	3.3E-06	mg/m^3
Selenium	2.3E-07	mg/m^3
Silver	1.0E-06	mg/m^3
Tetrachlorodibenzo-p-dioxin	1.4E-13	mg/m^3
Thallium	1.1E-07	mg/m^3
Thorium	2.9E-05	mg/m^3
Uranium	4.9E-04	mg/m^3
Vanadium	4.5E-06	mg/m^3
Zinc	1.3E-05	mg/m^3

References

Table I.IV-82 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	5.3E-09	NA	NA
4,4-DDE	3.6E-10	NA	NA
Antimony	5.0E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.2E-08	NA	NA
Aroclor-1260	2.9E-08	NA	NA
Arsenic	4.8E-07	NA	NA
Barium	5.2E-06	1.0E-04	5.2E-02
Beryllium	4.7E-08	NA	NA
Boron	1.6E-05	5.7E-03	2.8E-03
Cadmium	1.7E-07	NA	NA
Carbazole	1.2E-08	NA	NA
Chromium	7.0E-07	NA	NA
Cobalt	5.0E-07	3.0E-07	1.7E+00
Copper	1.3E-06	NA	NA
Cyanide	1.6E-08	NA	NA
Endrin	5.0E-10	NA	NA
Lead	1.3E-06	NA	NA
Manganese	4.1E-05	1.1E-04	3.8E-01
Mercury	3.5E-08	8.6E-05	4.0E-04
Molybdenum	2.6E-07	NA	NA
Nickel	9.0E-07	NA	NA
Selenium	6.3E-08	NA	NA
Silver	2.7E-07	NA	NA
Tetrachlorodibenzo-p-dioxin	3.9E-14	NA	NA
Thallium	3.0E-08	NA	NA
Thorium	7.8E-06	NA	NA
Uranium	1.4E-04	NA	NA
Vanadium	1.2E-06	NA	NA
Zinc	3.5E-06	NA	NA
	HQ Summation =		2.1E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	5.3E-09	NA	NA
4,4-DDE	3.6E-10	NA	NA
Antimony	5.0E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.2E-08	NA	NA
Aroclor-1260	2.9E-08	NA	NA
Arsenic	4.8E-07	1.5E+01	7.3E-06
Barium	5.2E-06	NA	NA
Beryllium	4.7E-08	8.4E+00	4.0E-07
Boron	1.6E-05	NA	NA
Cadmium	1.7E-07	6.1E+00	1.0E-06
Carbazole	1.2E-08	NA	NA
Chromium	7.0E-07	4.1E+01	2.9E-05
Cobalt	5.0E-07	NA	NA
Copper	1.3E-06	NA	NA
Cyanide	1.6E-08	NA	NA
Endrin	5.0E-10	NA	NA
Lead	1.3E-06	NA	NA
Manganese	4.1E-05	NA	NA
Mercury	3.5E-08	NA	NA
Molybdenum	2.6E-07	NA	NA
Nickel	9.0E-07	8.4E-01	7.6E-07
Selenium	6.3E-08	NA	NA
Silver	2.7E-07	NA	NA
Tetrachlorodibenzo-p-dioxin	3.9E-14	1.5E+05	5.9E-09
Thallium	3.0E-08	NA	NA
Thorium	7.8E-06	NA	NA
Uranium	1.4E-04	NA	NA
Vanadium	1.2E-06	NA	NA
Zinc	3.5E-06	NA	NA
	ILCR Summation =		3.8E-05

Table I.IV–83
Summary of Intake and Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR_o	Inhalation rate of gases (outdoors)	20 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
CA_o	Concentration of radionuclides in outdoor air	(see table below)

Cs-137	9.3E-05	pCi/m^3	Ru-106	4.4E-05	pCi/m^3
Np-237	2.6E-04	pCi/m^3	Sr-90	1.9E-04	pCi/m^3
Pa-231	3.0E-04	pCi/m^3	Tc-99	3.4E-03	pCi/m^3
Pb-210	5.4E-04	pCi/m^3	Th-228	9.9E-05	pCi/m^3
Pu-238	4.3E-04	pCi/m^3	Th-230	4.2E-04	pCi/m^3
Pu-239	7.2E-05	pCi/m^3	Th-232	2.5E-04	pCi/m^3
Pu-240	2.6E-04	pCi/m^3	U-234	1.7E-02	pCi/m^3
Ra-226	7.0E-05	pCi/m^3	U-235	3.8E-04	pCi/m^3
Ra-228	1.2E-04	pCi/m^3	U-236	1.2E-03	pCi/m^3
Rn-222	6.5E+00	pCi/m^3	U-238	5.5E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	4.6E+01	1.9E-11	8.7E-10
Np-237	1.3E+02	2.9E-08	3.8E-06
Pa-231	1.5E+02	3.6E-08	5.3E-06
Pb-210	2.6E+02	4.0E-09	1.1E-06
Pu-238	2.1E+02	3.9E-08	8.3E-06
Pu-239	3.5E+01	3.8E-08	1.3E-06
Pu-240	1.3E+02	3.8E-08	4.8E-06
Ra-226	3.4E+01	3.0E-09	1.0E-07
Ra-228	5.8E+01	6.9E-10	4.0E-08
Rn-222	3.2E+06	7.7E-12	2.5E-05
Ru-106	2.2E+01	4.4E-10	9.6E-09
Sr-90	9.2E+01	6.2E-11	5.7E-09
Tc-99	1.7E+03	8.3E-12	1.4E-08
Th-228	4.8E+01	7.8E-08	3.8E-06
Th-230	2.1E+02	2.9E-08	6.0E-06
Th-232	1.2E+02	2.8E-08	3.5E-06
U-234	8.5E+03	2.6E-08	2.2E-04
U-235	1.8E+02	2.5E-08	4.6E-06
U-236	6.1E+02	2.5E-08	1.5E-05
U-238	2.7E+03	5.2E-11	1.4E-07
		ILCR Summation =	3.0E-04

Table I.IV-84
Summary of Intake Quantitation (Chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Incidental Ingestion of Soil

Intake 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	1.00E-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 x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/kg
4,4-DDE	NA	mg/kg
Antimony	2.8E+01	mg/kg
Aroclor-1221	NA	mg/kg
Aroclor-1248	NA	mg/kg
Aroclor-1254	NA	mg/kg
Aroclor-1260	NA	mg/kg
Arsenic	9.0E+01	mg/kg
Barium	4.1E+02	mg/kg
Beryllium	4.7E+00	mg/kg
Boron	6.6E+02	mg/kg
Cadmium	5.9E+00	mg/kg
Carbazole	NA	mg/kg
Chromium	4.5E+01	mg/kg
Cobalt	2.1E+01	mg/kg
Copper	7.4E+01	mg/kg

Compound	Concentration	Units
Cyanide	1.2E+00	mg/kg
Endrin	NA	mg/kg
Lead	1.2E+02	mg/kg
Manganese	2.2E+03	mg/kg
Mercury	1.1E+00	mg/kg
Molybdenum	1.3E+01	mg/kg
Nickel	4.0E+01	mg/kg
Selenium	5.9E+00	mg/kg
Silver	1.7E+01	mg/kg
Tetrachlorodibenzo-p-dioxin	5.6E-06	mg/kg
Thallium	2.7E+00	mg/kg
Thorium	NA	mg/kg
Uranium	NA	mg/kg
Vanadium	5.0E+01	mg/kg
Zinc	3.5E+02	mg/kg

References

Table I.IV-84 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Incidental Ingestion of Soil

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	6.9E-05	4.0E-04	1.7E-01
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	2.2E-04	3.0E-04	7.4E-01
Barium	1.0E-03	7.0E-02	1.4E-02
Beryllium	1.2E-05	5.0E-03	2.3E-03
Boron	1.6E-03	9.0E-02	1.8E-02
Cadmium	1.5E-05	1.0E-03	1.5E-02
Carbazole	NA	NA	NA
Chromium	1.1E-04	5.0E-03	2.2E-02
Cobalt	5.1E-05	6.0E-02	8.5E-04
Copper	1.8E-04	NA	NA
Cyanide	3.0E-06	2.0E-02	1.5E-04
Endrin	NA	3.0E-04	NA
Lead	2.9E-04	NA	NA
Manganese	5.3E-03	1.4E-01	3.8E-02
Mercury	2.7E-06	3.0E-04	9.0E-03
Molybdenum	3.2E-05	5.0E-03	6.5E-03
Nickel	9.9E-05	2.0E-02	4.9E-03
Selenium	1.5E-05	5.0E-03	2.9E-03
Silver	4.2E-05	5.0E-03	8.5E-03
Tetrachlorodibenzo-p-dioxin	1.4E-11	NA	NA
Thallium	6.7E-06	8.0E-05	8.3E-02
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	NA
Vanadium	1.2E-04	7.0E-03	1.8E-02
Zinc	8.7E-04	3.0E-01	2.9E-03
	HQ Summation =		1.2E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	6.9E-05	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	2.2E-04	1.8E+00	4.0E-04
Barium	1.0E-03	NA	NA
Beryllium	1.2E-05	4.3E+00	5.0E-05
Boron	1.6E-03	NA	NA
Cadmium	1.5E-05	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	1.1E-04	NA	NA
Cobalt	5.1E-05	NA	NA
Copper	1.8E-04	NA	NA
Cyanide	3.0E-06	NA	NA
Endrin	NA	NA	NA
Lead	2.9E-04	NA	NA
Manganese	5.3E-03	NA	NA
Mercury	2.7E-06	NA	NA
Molybdenum	3.2E-05	NA	NA
Nickel	9.9E-05	NA	NA
Selenium	1.5E-05	NA	NA
Silver	4.2E-05	NA	NA
Tetrachlorodibenzo-p-dioxin	1.4E-11	1.5E+05	2.1E-06
Thallium	6.7E-06	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	1.2E-04	NA	NA
Zinc	8.7E-04	NA	NA
	ILCR Summation =		4.5E-04

Table I.IV-85
Summary of Intake and Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Incidental Ingestion of Soil

Intake 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		(see table below)

Cs-137	1.0E-03	pCi/mg	Ru-106	1.3E-03	pCi/mg
Np-237	5.0E-03	pCi/mg	Sr-90	6.1E-03	pCi/mg
Pa-231	1.4E-02	pCi/mg	Tc-99	3.2E-01	pCi/mg
Pb-210	2.0E-02	pCi/mg	Th-228	4.0E-04	pCi/mg
Pu-238	4.0E-02	pCi/mg	Th-230	5.0E-03	pCi/mg
Pu-239	5.3E-03	pCi/mg	Th-232	5.0E-03	pCi/mg
Pu-240	1.9E-02	pCi/mg	U-234	7.5E-01	pCi/mg
Ra-226	2.9E-03	pCi/mg	U-235	9.0E-03	pCi/mg
Ra-228	2.0E-03	pCi/mg	U-236	9.0E-03	pCi/mg
Rn-222	NA	pCi/mg	U-238	6.0E-02	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	4.4E+03	2.8E-11	1.2E-07
Np-237	2.2E+04	2.2E-10	4.9E-06
Pa-231	6.0E+04	9.2E-11	5.6E-06
Pb-210	8.6E+04	6.6E-10	5.7E-05
Pu-238	1.8E+05	2.2E-10	3.9E-05
Pu-239	2.3E+04	2.3E-10	5.4E-06
Pu-240	8.5E+04	2.3E-10	2.0E-05
Ra-226	1.3E+04	1.2E-10	1.5E-06
Ra-228	8.8E+03	1.0E-10	8.8E-07
Rn-222	NA	1.7E-12	NA
Ru-106	5.7E+03	9.5E-12	5.4E-08
Sr-90	2.7E+04	3.6E-11	9.6E-07
Tc-99	1.4E+06	1.3E-12	1.8E-06
Th-228	1.8E+03	5.5E-11	9.7E-08
Th-230	2.2E+04	1.3E-11	2.9E-07
Th-232	2.2E+04	1.2E-11	2.6E-07
U-234	3.3E+06	1.6E-11	5.3E-05
U-235	4.0E+04	1.6E-11	6.4E-07
U-236	4.0E+04	1.5E-11	6.0E-07
U-238	2.6E+05	2.8E-11	7.4E-06
		ILCR Summation =	2.0E-04

Table I.IV-86
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
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
2-Methylnaphthalene	NA	mg/l	Cyanide	NA	mg/l
4,4-DDE	NA	mg/l	Endrin	NA	mg/l
Antimony	NA	mg/l	Lead	NA	mg/l
Aroclor-1221	1.2E-02	mg/l	Manganese	NA	mg/l
Aroclor-1248	NA	mg/l	Mercury	NA	mg/l
Aroclor-1254	NA	mg/l	Molybdenum	NA	mg/l
Aroclor-1260	NA	mg/l	Nickel	NA	mg/l
Arsenic	NA	mg/l	Selenium	NA	mg/l
Barium	NA	mg/l	Silver	NA	mg/l
Beryllium	NA	mg/l	Tetrachlorodibenzo-p-dioxin	NA	mg/l
Boron	NA	mg/l	Thallium	NA	mg/l
Cadmium	NA	mg/l	Thorium	NA	mg/l
Carbazole	NA	mg/l	Uranium	NA	mg/l
Chromium	NA	mg/l	Vanadium	NA	mg/l
Cobalt	NA	mg/l	Zinc	NA	mg/l
Copper	NA	mg/l			

References

Table I.IV-86
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	NA	4.0E-04	0.0E+00
Aroclor-1221	3.3E-04	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	NA	3.0E-04	0.0E+00
Barium	NA	7.0E-02	0.0E+00
Beryllium	NA	5.0E-03	0.0E+00
Boron	NA	9.0E-02	0.0E+00
Cadmium	NA	1.0E-03	0.0E+00
Carbazole	NA	NA	NA
Chromium	NA	5.0E-03	0.0E+00
Cobalt	NA	6.0E-02	0.0E+00
Copper	NA	NA	NA
Cyanide	NA	2.0E-02	0.0E+00
Endrin	NA	3.0E-04	0.0E+00
Lead	NA	NA	NA
Manganese	NA	1.4E-01	0.0E+00
Mercury	NA	3.0E-04	0.0E+00
Molybdenum	NA	5.0E-03	0.0E+00
Nickel	NA	2.0E-02	0.0E+00
Selenium	NA	5.0E-03	0.0E+00
Silver	NA	5.0E-03	0.0E+00
Tetrachlorodibenzo-p-dioxin	NA	NA	NA
Thallium	NA	8.0E-05	0.0E+00
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	0.0E+00
Vanadium	NA	7.0E-03	0.0E+00
Zinc	NA	3.0E-01	0.0E+00
	HQ Summation =		0.0E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	NA	NA	NA
Aroclor-1221	3.3E-04	7.7E+00	2.6E-03
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	NA	1.8E+00	NA
Barium	NA	NA	NA
Beryllium	NA	4.3E+00	NA
Boron	NA	NA	NA
Cadmium	NA	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	NA	NA	NA
Cyanide	NA	NA	NA
Endrin	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Molybdenum	NA	NA	NA
Nickel	NA	NA	NA
Selenium	NA	NA	NA
Silver	NA	NA	NA
Tetrachlorodibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	NA	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	NA	NA	NA
	ILCR Summation =		2.6E-03

Table I.IV-87
Summary of Intake and Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
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)

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	3.3E+02	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	1.8E+04	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	3.1E+02	pCi/l
Ra-226	NA	pCi/l	U-235	8.3E+00	pCi/l
Ra-228	NA	pCi/l	U-236	3.4E+00	pCi/l
Rn-222	NA	pCi/l	U-238	1.9E+02	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	1.6E+07	2.2E-10	3.6E-03
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	8.8E+08	1.3E-12	1.1E-03
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	1.5E+07	1.6E-11	2.4E-04
U-235	4.1E+05	1.6E-11	6.5E-06
U-236	1.7E+05	1.5E-11	2.5E-06
U-238	9.2E+06	2.8E-11	2.6E-04
		ILCR Summation =	5.2E-03

Table I.IV-88
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Dermal Contact with Soil

Intake 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	Chemical 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 x 365)	25550 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	ABS	Concentrati	Units
2-Methylnaphthalene	3.0E-01	NA	mg/kg
4,4-DDE	3.0E-01	NA	mg/kg
Antimony	1.0E-02	2.8E+01	mg/kg
Aroclor-1221	6.0E-02	NA	mg/kg
Aroclor-1248	6.0E-02	NA	mg/kg
Aroclor-1254	6.0E-02	NA	mg/kg
Aroclor-1260	6.0E-02	NA	mg/kg
Arsenic	1.0E-03	9.0E+01	mg/kg
Barium	1.0E-02	4.1E+02	mg/kg
Beryllium	1.0E-02	4.7E+00	mg/kg
Boron	1.0E-02	6.6E+02	mg/kg
Cadmium	1.0E-02	5.9E+00	mg/kg
Carbazole	3.0E-01	NA	mg/kg
Chromium	1.0E-02	4.5E+01	mg/kg
Cobalt	1.0E-02	2.1E+01	mg/kg
Copper	1.0E-03	7.4E+01	mg/kg

Compound	ABS	Concentration	Units
Cyanide	1.0E-02	1.2E+00	mg/kg
Endrin	3.0E-01	NA	mg/kg
Lead	1.0E-02	1.2E+02	mg/kg
Manganese	1.0E-02	2.2E+03	mg/kg
Mercury	5.0E-02	1.1E+00	mg/kg
Molybdenum	1.0E-02	1.3E+01	mg/kg
Nickel	5.0E-04	4.0E+01	mg/kg
Selenium	1.0E-02	5.9E+00	mg/kg
Silver	1.0E-02	1.7E+01	mg/kg
Tetrachlorodibenzo-p-dioxin	3.0E-02	5.6E-06	mg/kg
Thallium	1.0E-02	2.7E+00	mg/kg
Thorium	1.0E-02	NA	mg/kg
Uranium	1.0E-02	NA	mg/kg
Vanadium	1.0E-03	5.0E+01	mg/kg
Zinc	1.0E-02	3.5E+02	mg/kg

References

Table I.IV-88 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Dermal Contact with Soil

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	2.2E-05	6.0E-05	3.7E-01
Aroclor-1221	NA	5.3E-05	NA
Aroclor-1248	NA	5.3E-05	NA
Aroclor-1254	NA	5.3E-05	NA
Aroclor-1260	NA	5.3E-05	NA
Arsenic	7.1E-06	2.9E-04	2.5E-02
Barium	3.2E-04	6.4E-02	5.1E-03
Beryllium	3.7E-06	5.0E-05	7.4E-02
Boron	5.2E-04	4.5E-03	1.1E-01
Cadmium	4.7E-06	5.0E-05	9.3E-02
Carbazole	NA	NA	NA
Chromium	3.5E-05	2.3E-03	1.6E-02
Cobalt	1.6E-05	2.7E-02	6.0E-04
Copper	5.8E-06	2.2E-02	2.6E-04
Cyanide	9.5E-07	NA	NA
Endrin	NA	2.7E-04	NA
Lead	9.2E-05	NA	NA
Manganese	1.7E-03	4.2E-03	4.0E-01
Mercury	4.3E-06	4.5E-05	9.6E-02
Molybdenum	1.0E-05	1.9E-03	5.4E-03
Nickel	1.6E-06	2.0E-03	7.9E-04
Selenium	4.6E-06	4.0E-03	1.2E-03
Silver	1.4E-05	NA	NA
Tetrachlorodibenzo-p-dioxin	1.3E-11	NA	NA
Thallium	2.1E-06	6.0E-05	3.5E-02
Thorium	NA	NA	NA
Uranium	NA	1.5E-04	NA
Vanadium	4.0E-06	3.5E-04	1.1E-02
Zinc	2.8E-04	7.5E-02	3.7E-03
	HQ Summation =		1.3E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.8E-01	NA
Antimony	2.2E-05	NA	NA
Aroclor-1221	NA	1.0E+01	NA
Aroclor-1248	NA	1.0E+01	NA
Aroclor-1254	NA	1.0E+01	NA
Aroclor-1260	NA	1.0E+01	NA
Arsenic	7.1E-06	1.9E+00	1.3E-05
Barium	3.2E-04	NA	NA
Beryllium	3.7E-06	4.3E+02	1.6E-03
Boron	5.2E-04	NA	NA
Cadmium	4.7E-06	NA	NA
Carbazole	NA	2.2E-02	NA
Chromium	3.5E-05	NA	NA
Cobalt	1.6E-05	NA	NA
Copper	5.8E-06	NA	NA
Cyanide	9.5E-07	NA	NA
Endrin	NA	NA	NA
Lead	9.2E-05	NA	NA
Manganese	1.7E-03	NA	NA
Mercury	4.3E-06	NA	NA
Molybdenum	1.0E-05	NA	NA
Nickel	1.6E-06	NA	NA
Selenium	4.6E-06	NA	NA
Silver	1.4E-05	NA	NA
Tetrachlorodibenzo-p-dioxin	1.3E-11	3.0E+05	4.0E-06
Thallium	2.1E-06	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	4.0E-06	NA	NA
Zinc	2.8E-04	NA	NA
	ILCR Summation =		1.6E-03

Table I.IV-89
Summary of Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership Via External Radiation

Exposure Equation = $[CR \times EF \times EDn \times ET_i \times (1-SH_i)] + [CR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.95 (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	0 (unitless)
CR	Radionuclide specific concentrations	(see table below)

Cs-137	1.0E+00 pCi/g	Ru-106	1.3E+00 pCi/g
Np-237	5.0E+00 pCi/g	Sr-90	6.1E+00 pCi/g
Pa-231	1.4E+01 pCi/g	Tc-99	3.2E+02 pCi/g
Pb-210	2.0E+01 pCi/g	Th-228	4.0E-01 pCi/g
Pu-238	4.0E+01 pCi/g	Th-230	5.0E+00 pCi/g
Pu-239	5.3E+00 pCi/g	Th-232	5.0E+00 pCi/g
Pu-240	1.9E+01 pCi/g	U-234	7.5E+02 pCi/g
Ra-226	2.9E+00 pCi/g	U-235	9.0E+00 pCi/g
Ra-228	2.0E+00 pCi/g	U-236	9.0E+00 pCi/g
Rn-222	NA pCi/g	U-238	6.0E+01 pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs-137	4.1E+01	2.0E-06	8.2E-05
Np-237	2.1E+02	4.3E-07	8.9E-05
Pa-231	5.6E+02	2.6E-08	1.5E-05
Pb-210	8.1E+02	1.6E-10	1.3E-07
Pu-238	1.6E+03	2.8E-11	4.6E-08
Pu-239	2.2E+02	1.7E-11	3.7E-09
Pu-240	8.0E+02	2.7E-11	2.1E-08
Ra-226	1.2E+02	6.0E-06	7.2E-04
Ra-228	8.2E+01	2.9E-06	2.4E-04
Rn-222	NA	5.9E-06	NA
Ru-106	5.4E+01	NA	NA
Sr-90	2.5E+02	NA	NA
Tc-99	1.3E+04	6.0E-13	7.9E-09
Th-228	1.6E+01	5.6E-06	9.2E-05
Th-230	2.1E+02	5.4E-11	1.1E-08
Th-232	2.1E+02	2.6E-11	5.4E-09
U-234	3.1E+04	3.0E-11	9.3E-07
U-235	3.7E+02	2.4E-07	8.9E-05
U-236	3.7E+02	2.4E-11	8.9E-09
U-238	2.5E+03	3.6E-08	8.9E-05
		ILCR Summation =	1.4E-03

Table I.IV-90
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
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	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (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
2-Methylnaphthalene	0.0E+00	mg/kg
4,4-DDE	5.9E-04	mg/kg
Antimony	1.1E-02	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	7.5E-03	mg/kg
Aroclor-1260	9.6E-03	mg/kg
Arsenic	2.5E-02	mg/kg
Barium	1.2E-01	mg/kg
Beryllium	7.6E-04	mg/kg
Boron	1.8E+01	mg/kg
Cadmium	5.4E-02	mg/kg
Carbazole	0.0E+00	mg/kg
Chromium	7.9E-02	mg/kg
Cobalt	3.6E-01	mg/kg
Copper	4.1E+00	mg/kg
Cyanide	2.5E-07	mg/kg
Endrin	3.1E-06	mg/kg
Lead	1.9E-02	mg/kg
Manganese	5.1E+00	mg/kg
Mercury	2.4E+00	mg/kg
Molybdenum	1.4E-01	mg/kg
Nickel	4.7E-01	mg/kg
Selenium	1.7E-02	mg/kg
Silver	3.7E-01	mg/kg
Tetrachlorodibenzo-p-dioxin	0.0E+00	mg/kg
Thallium	1.6E-02	mg/kg
Thorium	0.0E+00	mg/kg
Uranium	1.2E-07	mg/kg
Vanadium	5.0E-02	mg/kg
Zinc	4.8E+02	mg/kg

References

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Table I.IV-90 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	6.1E-07	NA	NA
Antimony	1.1E-05	4.0E-04	2.8E-02
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	7.8E-06	NA	NA
Aroclor-1260	9.9E-06	NA	NA
Arsenic	2.6E-05	3.0E-04	8.7E-02
Barium	1.2E-04	7.0E-02	1.7E-03
Beryllium	7.8E-07	5.0E-03	1.6E-04
Boron	1.8E-02	9.0E-02	2.1E-01
Cadmium	5.5E-05	1.0E-03	5.5E-02
Carbazole	NA	NA	NA
Chromium	8.1E-05	5.0E-03	1.6E-02
Cobalt	3.7E-04	6.0E-02	6.2E-03
Copper	4.3E-03	NA	NA
Cyanide	2.6E-10	2.0E-02	1.3E-08
Endrin	3.2E-09	3.0E-04	1.1E-05
Lead	2.0E-05	NA	NA
Manganese	5.2E-03	1.4E-01	3.7E-02
Mercury	2.5E-03	3.0E-04	8.3E+00
Molybdenum	1.4E-04	5.0E-03	2.8E-02
Nickel	4.9E-04	2.0E-02	2.4E-02
Selenium	1.7E-05	5.0E-03	3.4E-03
Silver	3.8E-04	5.0E-03	7.6E-02
Tetrachlorodibenzo-p-dioxin	NA	NA	NA
Thallium	1.6E-05	8.0E-05	2.0E-01
Thorium	NA	NA	NA
Uranium	1.3E-10	3.0E-03	4.2E-08
Vanadium	5.2E-05	7.0E-03	7.4E-03
Zinc	5.0E-01	3.0E-01	1.7E+00
	HQ Summation =		1.1E+01

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	6.1E-07	3.4E-01	2.1E-07
Antimony	1.1E-05	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	7.8E-06	7.7E+00	6.0E-05
Aroclor-1260	9.9E-06	7.7E+00	7.6E-05
Arsenic	2.6E-05	1.8E+00	4.7E-05
Barium	1.2E-04	NA	NA
Beryllium	7.8E-07	4.3E+00	3.3E-06
Boron	1.8E-02	NA	NA
Cadmium	5.5E-05	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	8.1E-05	NA	NA
Cobalt	3.7E-04	NA	NA
Copper	4.3E-03	NA	NA
Cyanide	2.6E-10	NA	NA
Endrin	3.2E-09	NA	NA
Lead	2.0E-05	NA	NA
Manganese	5.2E-03	NA	NA
Mercury	2.5E-03	NA	NA
Molybdenum	1.4E-04	NA	NA
Nickel	4.9E-04	NA	NA
Selenium	1.7E-05	NA	NA
Silver	3.8E-04	NA	NA
Tetrachlorodibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	1.6E-05	NA	NA
Thorium	NA	NA	NA
Uranium	1.3E-10	NA	NA
Vanadium	5.2E-05	NA	NA
Zinc	5.0E-01	NA	NA
	ILCR Summation =		1.9E-04

Table I.IV-91
Summary of Intake and Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in meat	

Cs-137	5.26E+01	pCi/kg	Ru-106	0.00E+00	pCi/kg
Np-237	6.16E-03	pCi/kg	Sr-90	1.25E-01	pCi/kg
Pa-231	1.7E-05	pCi/kg	Tc-99	7.95E+00	pCi/kg
Pb-210	0.0E+00	pCi/kg	Th-228	1.21E-03	pCi/kg
Pu-238	2.4E-05	pCi/kg	Th-230	3.29E-04	pCi/kg
Pu-239	3.3E-06	pCi/kg	Th-232	6.93E-03	pCi/kg
Pu-240	1.2E-05	pCi/kg	U-234	4.82E+00	pCi/kg
Ra-226	9.6E-02	pCi/kg	U-235	2.00E-01	pCi/kg
Ra-228	1.7E-01	pCi/kg	U-236	1.28E+00	pCi/kg
Rn-222	0.0E+00	pCi/kg	U-238	8.60E+00	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	9.7E+04	2.8E-11	2.7E-06
Np-237	1.1E+01	2.2E-10	2.5E-09
Pa-231	3.1E-02	9.2E-11	2.8E-12
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	4.4E-02	2.2E-10	9.6E-12
Pu-239	6.0E-03	2.3E-10	1.4E-12
Pu-240	2.2E-02	2.3E-10	5.0E-12
Ra-226	1.8E+02	1.2E-10	2.1E-08
Ra-228	3.1E+02	1.0E-10	3.1E-08
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	0.0E+00	9.5E-12	NA
Sr-90	2.3E+02	3.6E-11	8.3E-09
Tc-99	1.5E+04	1.3E-12	1.9E-08
Th-228	2.2E+00	5.5E-11	1.2E-10
Th-230	6.1E-01	1.3E-11	7.9E-12
Th-232	1.3E+01	1.2E-11	1.5E-10
U-234	8.9E+03	1.6E-11	1.4E-07
U-235	3.7E+02	1.6E-11	5.9E-09
U-236	2.4E+03	1.5E-11	3.5E-08
U-238	1.6E+04	2.8E-11	4.4E-07
		ILCR Summation =	3.4E-06

Table I.IV-92
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
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	0.3	l/day
FI	Fraction ingested from contaminated source	1	(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
2-Methylnaphthalene	0.0E+00	mg/l
4,4-DDE	1.1E-04	mg/l
Antimony	1.1E-03	mg/l
Aroclor-1221	0.0E+00	mg/l
Aroclor-1248	0.0E+00	mg/l
Aroclor-1254	2.4E-03	mg/l
Aroclor-1260	3.0E-03	mg/l
Arsenic	7.6E-04	mg/l
Barium	2.7E-01	mg/l
Beryllium	6.8E-07	mg/l
Boron	3.4E+01	mg/l
Cadmium	9.7E-02	mg/l
Carbazole	0.0E+00	mg/l
Chromium	2.2E-02	mg/l
Cobalt	3.6E-02	mg/l
Copper	6.2E-01	mg/l

Compound	Concentration	Units
Cyanide	8.1E-08	mg/l
Endrin	4.5E-07	mg/l
Lead	1.6E-02	mg/l
Manganese	4.4E+00	mg/l
Mercury	4.4E-03	mg/l
Molybdenum	3.4E-02	mg/l
Nickel	7.9E-02	mg/l
Selenium	4.4E-03	mg/l
Silver	2.5E+00	mg/l
Tetrachlorodibenzo-p-dioxin	0.0E+00	mg/l
Thallium	7.8E-04	mg/l
Thorium	0.0E+00	mg/l
Uranium	3.7E-07	mg/l
Vanadium	4.0E-04	mg/l
Zinc	4.8E+01	mg/l

References

Table I.IV-92 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.7E-07	NA	NA
Antimony	4.4E-06	4.0E-04	1.1E-02
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.8E-06	NA	NA
Aroclor-1260	1.2E-05	NA	NA
Arsenic	3.1E-06	3.0E-04	1.0E-02
Barium	1.1E-03	7.0E-02	1.6E-02
Beryllium	2.8E-09	5.0E-03	5.6E-07
Boron	1.4E-01	9.0E-02	1.5E+00
Cadmium	4.0E-04	1.0E-03	4.0E-01
Carbazole	NA	NA	NA
Chromium	8.8E-05	5.0E-03	1.8E-02
Cobalt	1.5E-04	6.0E-02	2.5E-03
Copper	2.6E-03	NA	NA
Cyanide	3.3E-10	2.0E-02	1.7E-08
Endrin	1.8E-09	3.0E-04	6.2E-06
Lead	6.6E-05	NA	NA
Manganese	1.8E-02	1.4E-01	1.3E-01
Mercury	1.8E-05	3.0E-04	6.0E-02
Molybdenum	1.4E-04	5.0E-03	2.8E-02
Nickel	3.3E-04	2.0E-02	1.6E-02
Selenium	1.8E-05	5.0E-03	3.6E-03
Silver	1.0E-02	5.0E-03	2.0E+00
Tetrachlorodibenzo-p-dioxin	NA	NA	NA
Thallium	3.2E-06	8.0E-05	4.0E-02
Thorium	NA	NA	NA
Uranium	1.5E-09	3.0E-03	5.0E-07
Vanadium	1.7E-06	7.0E-03	2.4E-04
Zinc	2.0E-01	3.0E-01	6.6E-01
	HQ Summation =		5.0E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.7E-07	3.4E-01	1.6E-07
Antimony	4.4E-06	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	9.8E-06	7.7E+00	7.5E-05
Aroclor-1260	1.2E-05	7.7E+00	9.6E-05
Arsenic	3.1E-06	1.8E+00	5.6E-06
Barium	1.1E-03	NA	NA
Beryllium	2.8E-09	4.3E+00	1.2E-08
Boron	1.4E-01	NA	NA
Cadmium	4.0E-04	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	8.8E-05	NA	NA
Cobalt	1.5E-04	NA	NA
Copper	2.6E-03	NA	NA
Cyanide	3.3E-10	NA	NA
Endrin	1.8E-09	NA	NA
Lead	6.6E-05	NA	NA
Manganese	1.8E-02	NA	NA
Mercury	1.8E-05	NA	NA
Molybdenum	1.4E-04	NA	NA
Nickel	3.3E-04	NA	NA
Selenium	1.8E-05	NA	NA
Silver	1.0E-02	NA	NA
Tetrachlorodibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	3.2E-06	NA	NA
Thorium	NA	NA	NA
Uranium	1.5E-09	NA	NA
Vanadium	1.7E-06	NA	NA
Zinc	2.0E-01	NA	NA
	ILCR Summation =		1.8E-04

Table I.IV-93
Summary of Intake and Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.3 l/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs-137	1.84E+01	pCi/l	Ru-106	1.79E-25	pCi/l
Np-237	5.88E-04	pCi/l	Sr-90	2.23E-19	pCi/l
Pa-231	1.0E-07	pCi/l	Tc-99	1.72E-17	pCi/l
Pb-210	0.0E+00	pCi/l	Th-228	9.65E-04	pCi/l
Pu-238	4.7E-06	pCi/l	Th-230	2.74E-04	pCi/l
Pu-239	6.5E-07	pCi/l	Th-232	5.87E-03	pCi/l
Pu-240	2.4E-06	pCi/l	U-234	1.51E+01	pCi/l
Ra-226	2.1E-01	pCi/l	U-235	6.15E-01	pCi/l
Ra-228	3.8E-01	pCi/l	U-236	3.85E+00	pCi/l
Rn-222	0.0E+00	pCi/l	U-238	2.94E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.4E+05	2.8E-11	3.8E-06
Np-237	4.3E+00	2.2E-10	9.5E-10
Pa-231	7.6E-04	9.2E-11	7.0E-14
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	3.5E-02	2.2E-10	7.7E-12
Pu-239	4.8E-03	2.3E-10	1.1E-12
Pu-240	1.7E-02	2.3E-10	4.0E-12
Ra-226	1.6E+03	1.2E-10	1.9E-07
Ra-228	2.8E+03	1.0E-10	2.8E-07
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	1.3E-21	9.5E-12	1.2E-32
Sr-90	1.6E-15	3.6E-11	5.9E-26
Tc-99	1.3E-13	1.3E-12	1.6E-25
Th-228	7.1E+00	5.5E-11	3.9E-10
Th-230	2.0E+00	1.3E-11	2.6E-11
Th-232	4.3E+01	1.2E-11	5.2E-10
U-234	1.1E+05	1.6E-11	1.8E-06
U-235	4.5E+03	1.6E-11	7.2E-08
U-236	2.8E+04	1.5E-11	4.2E-07
U-238	2.2E+05	2.8E-11	6.1E-06
		ILCR Summation =	1.3E-05

Table I.IV-94
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
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
2-Methylnaphthalene	5.3E-10	mg/kg
4,4-DDE	3.9E-04	mg/kg
Antimony	6.8E-02	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	2.4E-03	mg/kg
Aroclor-1260	1.4E-03	mg/kg
Arsenic	1.3E-02	mg/kg
Barium	6.2E-01	mg/kg
Beryllium	3.2E-03	mg/kg
Boron	9.6E+01	mg/kg
Cadmium	2.2E-01	mg/kg
Carbazole	1.0E-09	mg/kg
Chromium	3.2E-02	mg/kg
Cobalt	3.6E-02	mg/kg
Copper	2.2E+00	mg/kg

Compound	Concentration	Units
Cyanide	3.1E-09	mg/kg
Endrin	1.3E-06	mg/kg
Lead	9.0E-02	mg/kg
Manganese	2.1E+01	mg/kg
Mercury	1.8E-02	mg/kg
Molybdenum	1.7E+00	mg/kg
Nickel	5.8E-01	mg/kg
Selenium	6.8E-03	mg/kg
Silver	2.6E-01	mg/kg
Tetrachlorodibenzo-p-dioxin	2.8E-15	mg/kg
Thallium	9.5E-05	mg/kg
Thorium	3.1E-07	mg/kg
Uranium	7.9E-06	mg/kg
Vanadium	3.3E-02	mg/kg
Zinc	2.5E+01	mg/kg

References

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Table I.IV-94 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
Via Ingestion of Vegetables and Fruits

	HQ Calculation		
Compound	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	3.2E-07	NA	NA
Antimony	5.7E-05	4.0E-04	1.4E-01
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.0E-06	NA	NA
Aroclor-1260	1.2E-06	NA	NA
Arsenic	1.1E-05	3.0E-04	3.6E-02
Barium	5.2E-04	7.0E-02	7.4E-03
Beryllium	2.7E-06	5.0E-03	5.4E-04
Boron	8.0E-02	9.0E-02	8.9E-01
Cadmium	1.9E-04	1.0E-03	1.9E-01
Carbazole	8.3E-13	NA	NA
Chromium	2.6E-05	5.0E-03	5.3E-03
Cobalt	3.0E-05	6.0E-02	5.1E-04
Copper	1.8E-03	NA	NA
Cyanide	2.6E-12	2.0E-02	1.3E-10
Endrin	1.1E-09	3.0E-04	3.7E-06
Lead	7.6E-05	NA	NA
Manganese	1.7E-02	1.4E-01	1.2E-01
Mercury	1.5E-05	3.0E-04	5.1E-02
Molybdenum	1.4E-03	5.0E-03	2.8E-01
Nickel	4.9E-04	2.0E-02	2.4E-02
Selenium	5.6E-06	5.0E-03	1.1E-03
Silver	2.2E-04	5.0E-03	4.3E-02
Tetrachlorodibenzo-p-dioxin	2.3E-18	NA	NA
Thallium	8.0E-08	8.0E-05	1.0E-03
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	3.0E-03	2.2E-06
Vanadium	2.8E-05	7.0E-03	4.0E-03
Zinc	2.1E-02	3.0E-01	6.9E-02
	HQ Summation =		1.9E+00

	ILCR Calculation		
Compound	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	3.2E-07	3.4E-01	1.1E-07
Antimony	5.7E-05	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	2.0E-06	7.7E+00	1.5E-05
Aroclor-1260	1.2E-06	7.7E+00	8.9E-06
Arsenic	1.1E-05	1.8E+00	2.0E-05
Barium	5.2E-04	NA	NA
Beryllium	2.7E-06	4.3E+00	1.2E-05
Boron	8.0E-02	NA	NA
Cadmium	1.9E-04	NA	NA
Carbazole	8.3E-13	2.0E-02	1.7E-14
Chromium	2.6E-05	NA	NA
Cobalt	3.0E-05	NA	NA
Copper	1.8E-03	NA	NA
Cyanide	2.6E-12	NA	NA
Endrin	1.1E-09	NA	NA
Lead	7.6E-05	NA	NA
Manganese	1.7E-02	NA	NA
Mercury	1.5E-05	NA	NA
Molybdenum	1.4E-03	NA	NA
Nickel	4.9E-04	NA	NA
Selenium	5.6E-06	NA	NA
Silver	2.2E-04	NA	NA
Tetrachlorodibenzo-p-dioxin	2.3E-18	1.5E+05	3.5E-13
Thallium	8.0E-08	NA	NA
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	NA	NA
Vanadium	2.8E-05	NA	NA
Zinc	2.1E-02	NA	NA
	ILCR Summation =		5.6E-05

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Table I.IV–95
Summary of Intake and Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Adult (Perched Water) Future Land Use Without Federal Ownership
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	

Cs-137	7.49E+00	pCi/kg	Ru-106	4.40E-11	pCi/kg
Np-237	3.58E-01	pCi/kg	Sr-90	3.36E-09	pCi/kg
Pa-231	2.7E-06	pCi/kg	Tc-99	1.01E-06	pCi/kg
Pb-210	4.0E+00	pCi/kg	Th-228	1.42E-02	pCi/kg
Pu-238	1.8E-03	pCi/kg	Th-230	2.19E-03	pCi/kg
Pu-239	2.4E-04	pCi/kg	Th-232	2.17E-02	pCi/kg
Pu-240	8.8E-04	pCi/kg	U-234	5.29E+02	pCi/kg
Ra-226	2.5E-01	pCi/kg	U-235	1.47E+01	pCi/kg
Ra-228	4.4E-01	pCi/kg	U-236	1.72E+01	pCi/kg
Rn-222	3.6E-01	pCi/kg	U-238	2.98E+03	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.1E+04	2.8E-11	3.1E-07
Np-237	5.3E+02	2.2E-10	1.2E-07
Pa-231	4.0E-03	9.2E-11	3.7E-13
Pb-210	6.0E+03	6.6E-10	4.0E-06
Pu-238	2.6E+00	2.2E-10	5.8E-10
Pu-239	3.6E-01	2.3E-10	8.3E-11
Pu-240	1.3E+00	2.3E-10	3.0E-10
Ra-226	3.7E+02	1.2E-10	4.5E-08
Ra-228	6.6E+02	1.0E-10	6.6E-08
Rn-222	5.4E+02	1.7E-12	9.2E-10
Ru-106	6.6E-08	9.5E-12	6.3E-19
Sr-90	5.0E-06	3.6E-11	1.8E-16
Tc-99	1.5E-03	1.3E-12	2.0E-15
Th-228	2.1E+01	5.5E-11	1.2E-09
Th-230	3.3E+00	1.3E-11	4.3E-11
Th-232	3.2E+01	1.2E-11	3.9E-10
U-234	7.9E+05	1.6E-11	1.3E-05
U-235	2.2E+04	1.6E-11	3.5E-07
U-236	2.6E+04	1.5E-11	3.8E-07
U-238	4.5E+06	2.8E-11	1.2E-04
		ILCR Summation =	1.4E-04

Table I.IV-96
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Intake Equation = $\frac{CS \times EF \times ED \times IR}{BW \times AT}$

IR_o	Inhalation rate of gases (outdoors)	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 x 365)	2190 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	2.0E-08	mg/m^3
4,4-DDE	1.3E-09	mg/m^3
Antimony	1.8E-06	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-07	mg/m^3
Aroclor-1260	1.1E-07	mg/m^3
Arsenic	1.8E-06	mg/m^3
Barium	1.9E-05	mg/m^3
Beryllium	1.7E-07	mg/m^3
Boron	5.8E-05	mg/m^3
Cadmium	6.1E-07	mg/m^3
Carbazole	4.3E-08	mg/m^3
Chromium	2.6E-06	mg/m^3
Cobalt	1.8E-06	mg/m^3
Copper	4.6E-06	mg/m^3

Compound	Concentration	Units
Cyanide	5.9E-08	mg/m^3
Endrin	1.8E-09	mg/m^3
Lead	4.7E-06	mg/m^3
Manganese	1.5E-04	mg/m^3
Mercury	1.3E-07	mg/m^3
Molybdenum	9.6E-07	mg/m^3
Nickel	3.3E-06	mg/m^3
Selenium	2.3E-07	mg/m^3
Silver	1.0E-06	mg/m^3
Tetrachlordibenzo-p-dioxin	1.4E-13	mg/m^3
Thallium	1.1E-07	mg/m^3
Thorium	2.9E-05	mg/m^3
Uranium	4.9E-04	mg/m^3
Vanadium	4.5E-06	mg/m^3
Zinc	1.3E-05	mg/m^3

References

Table I.IV-96 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	1.5E-08	NA	NA
4,4-DDE	1.0E-09	NA	NA
Antimony	1.4E-06	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.6E-07	NA	NA
Aroclor-1260	8.1E-08	NA	NA
Arsenic	1.4E-06	NA	NA
Barium	1.5E-05	1.0E-04	1.5E-01
Beryllium	1.3E-07	NA	NA
Boron	4.4E-05	5.7E-03	7.8E-03
Cadmium	4.7E-07	NA	NA
Carbazole	3.3E-08	NA	NA
Chromium	2.0E-06	NA	NA
Cobalt	1.4E-06	3.0E-07	4.6E+00
Copper	3.5E-06	NA	NA
Cyanide	4.5E-08	NA	NA
Endrin	1.4E-09	NA	NA
Lead	3.6E-06	NA	NA
Manganese	1.2E-04	1.1E-04	1.1E+00
Mercury	9.7E-08	8.6E-05	1.1E-03
Molybdenum	7.4E-07	NA	NA
Nickel	2.5E-06	NA	NA
Selenium	1.8E-07	NA	NA
Silver	7.7E-07	NA	NA
Tetrachlordibenzo-p-dioxin	1.1E-13	NA	NA
Thallium	8.4E-08	NA	NA
Thorium	2.2E-05	NA	NA
Uranium	3.8E-04	NA	NA
Vanadium	3.5E-06	NA	NA
Zinc	9.9E-06	NA	NA
	HQ Summation =		5.8E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	1.3E-09	NA	NA
4,4-DDE	8.7E-11	NA	NA
Antimony	1.2E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.2E-08	NA	NA
Aroclor-1260	7.0E-09	NA	NA
Arsenic	1.2E-07	1.5E+01	1.7E-06
Barium	1.3E-06	NA	NA
Beryllium	1.1E-08	8.4E+00	9.6E-08
Boron	3.8E-06	NA	NA
Cadmium	4.0E-08	6.1E+00	2.5E-07
Carbazole	2.8E-09	NA	NA
Chromium	1.7E-07	4.1E+01	6.9E-06
Cobalt	1.2E-07	NA	NA
Copper	3.0E-07	NA	NA
Cyanide	3.9E-09	NA	NA
Endrin	1.2E-10	NA	NA
Lead	3.1E-07	NA	NA
Manganese	9.9E-06	NA	NA
Mercury	8.3E-09	NA	NA
Molybdenum	6.3E-08	NA	NA
Nickel	2.2E-07	8.4E-01	1.8E-07
Selenium	1.5E-08	NA	NA
Silver	6.6E-08	NA	NA
Tetrachlordibenzo-p-dioxin	9.4E-15	1.5E+05	1.4E-09
Thallium	7.2E-09	NA	NA
Thorium	1.9E-06	NA	NA
Uranium	3.2E-05	NA	NA
Vanadium	3.0E-07	NA	NA
Zinc	8.5E-07	NA	NA
	ILCR Summation =		9.1E-06

Table I.IV–97
Summary of Intake and Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Inhalation of Gases and Particulates

Intake Equation = Ca X EF X EDn X IR

IR_o	Inhalation rate of gases (outdoors)	12 m^3/day
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Ca	Concentration of radionuclides in air	(see table below)

Cs-137	9.3E-05	pCi/m^3	Ru-106	4.4E-05	pCi/m^3
Np-237	2.6E-04	pCi/m^3	Sr-90	1.9E-04	pCi/m^3
Pa-231	3.0E-04	pCi/m^3	Tc-99	3.4E-03	pCi/m^3
Pb-210	5.4E-04	pCi/m^3	Th-228	9.9E-05	pCi/m^3
Pu-238	4.3E-04	pCi/m^3	Th-230	4.2E-04	pCi/m^3
Pu-239	7.2E-05	pCi/m^3	Th-232	2.5E-04	pCi/m^3
Pu-240	2.6E-04	pCi/m^3	U-234	1.7E-02	pCi/m^3
Ra-226	7.0E-05	pCi/m^3	U-235	3.8E-04	pCi/m^3
Ra-228	1.2E-04	pCi/m^3	U-236	1.2E-03	pCi/m^3
Rn-222	6.5E+00	pCi/m^3	U-238	5.5E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	2.3E+00	1.9E-11	4.5E-11
Np-237	6.7E+00	2.9E-08	1.9E-07
Pa-231	7.6E+00	3.6E-08	2.7E-07
Pb-210	1.4E+01	4.0E-09	5.4E-08
Pu-238	1.1E+01	3.9E-08	4.3E-07
Pu-239	1.8E+00	3.8E-08	6.9E-08
Pu-240	6.6E+00	3.8E-08	2.5E-07
Ra-226	1.8E+00	3.0E-09	5.3E-09
Ra-228	3.0E+00	6.9E-10	2.1E-09
Rn-222	1.6E+05	7.7E-12	1.3E-06
Ru-106	1.1E+00	4.4E-10	4.9E-10
Sr-90	4.7E+00	6.2E-11	2.9E-10
Tc-99	8.6E+01	8.3E-12	7.2E-10
Th-228	2.5E+00	7.8E-08	1.9E-07
Th-230	1.1E+01	2.9E-08	3.1E-07
Th-232	6.4E+00	2.8E-08	1.8E-07
U-234	4.4E+02	2.6E-08	1.1E-05
U-235	9.5E+00	2.5E-08	2.4E-07
U-236	3.1E+01	2.5E-08	7.8E-07
U-238	1.4E+02	5.2E-11	7.2E-09
		ILCR Summation =	1.6E-05

Table I.IV-98
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Incidental Ingestion of Soil/Sediment

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Intake 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	1.00E-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 x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/kg
4,4-DDE	NA	mg/kg
Antimony	2.8E+01	mg/kg
Aroclor-1221	NA	mg/kg
Aroclor-1248	NA	mg/kg
Aroclor-1254	NA	mg/kg
Aroclor-1260	NA	mg/kg
Arsenic	9.0E+01	mg/kg
Barium	4.1E+02	mg/kg
Beryllium	4.7E+00	mg/kg
Boron	6.6E+02	mg/kg
Cadmium	5.9E+00	mg/kg
Carbazole	NA	mg/kg
Chromium	4.5E+01	mg/kg
Cobalt	2.1E+01	mg/kg
Copper	7.4E+01	mg/kg

Compound	Concentration	Units
Cyanide	1.2E+00	mg/kg
Endrin	NA	mg/kg
Lead	1.2E+02	mg/kg
Manganese	2.2E+03	mg/kg
Mercury	1.1E+00	mg/kg
Molybdenum	1.3E+01	mg/kg
Nickel	4.0E+01	mg/kg
Selenium	5.9E+00	mg/kg
Silver	1.7E+01	mg/kg
Tetrachlordibenzo-p-dioxin	5.6E-06	mg/kg
Thallium	2.7E+00	mg/kg
Thorium	NA	mg/kg
Uranium	NA	mg/kg
Vanadium	5.0E+01	mg/kg
Zinc	3.5E+02	mg/kg

References

Table I.IV-98 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Incidental Ingestion of Soil/Sediment

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	3.6E-04	4.0E-04	8.9E-01
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	1.1E-03	3.0E-04	3.8E+00
Barium	5.2E-03	7.0E-02	7.5E-02
Beryllium	6.0E-05	5.0E-03	1.2E-02
Boron	8.4E-03	9.0E-02	9.3E-02
Cadmium	7.6E-05	1.0E-03	7.6E-02
Carbazole	NA	NA	NA
Chromium	5.7E-04	5.0E-03	1.1E-01
Cobalt	2.6E-04	6.0E-02	4.4E-03
Copper	9.4E-04	NA	NA
Cyanide	1.5E-05	2.0E-02	7.7E-04
Endrin	NA	3.0E-04	NA
Lead	1.5E-03	NA	NA
Manganese	2.7E-02	1.4E-01	2.0E-01
Mercury	1.4E-05	3.0E-04	4.7E-02
Molybdenum	1.7E-04	5.0E-03	3.3E-02
Nickel	5.1E-04	2.0E-02	2.6E-02
Selenium	7.5E-05	5.0E-03	1.5E-02
Silver	2.2E-04	5.0E-03	4.4E-02
Tetrachlordibenzo-p-dioxin	7.2E-11	NA	NA
Thallium	3.5E-05	8.0E-05	4.3E-01
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	NA
Vanadium	6.4E-04	7.0E-03	9.2E-02
Zinc	4.5E-03	3.0E-01	1.5E-02
	HQ Summation =		6.0E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	3.1E-05	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	9.8E-05	1.8E+00	1.8E-04
Barium	4.5E-04	NA	NA
Beryllium	5.2E-06	4.3E+00	2.2E-05
Boron	7.2E-04	NA	NA
Cadmium	6.5E-06	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	4.9E-05	NA	NA
Cobalt	2.3E-05	NA	NA
Copper	8.1E-05	NA	NA
Cyanide	1.3E-06	NA	NA
Endrin	NA	NA	NA
Lead	1.3E-04	NA	NA
Manganese	2.4E-03	NA	NA
Mercury	1.2E-06	NA	NA
Molybdenum	1.4E-05	NA	NA
Nickel	4.4E-05	NA	NA
Selenium	6.5E-06	NA	NA
Silver	1.9E-05	NA	NA
Tetrachlordibenzo-p-dioxin	6.1E-12	1.5E+05	9.2E-07
Thallium	3.0E-06	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	5.5E-05	NA	NA
Zinc	3.9E-04	NA	NA
	ILCR Summation =		2.0E-04

Table I.IV-99
Summary of Intake and Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Incidental Ingestion of Soil/Sediment

Intake 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	(see table below)

Cs-137	1.0E-03	pCi/mg	Ru-106	1.3E-03	pCi/mg
Np-237	5.0E-03	pCi/mg	Sr-90	6.1E-03	pCi/mg
Pa-231	1.4E-02	pCi/mg	Tc-99	3.2E-01	pCi/mg
Pb-210	2.0E-02	pCi/mg	Th-228	4.0E-04	pCi/mg
Pu-238	4.0E-02	pCi/mg	Th-230	NA	pCi/mg
Pu-239	5.3E-03	pCi/mg	Th-232	NA	pCi/mg
Pu-240	1.9E-02	pCi/mg	U-234	2.9E+00	pCi/mg
Ra-226	2.9E-03	pCi/mg	U-235	9.0E-03	pCi/mg
Ra-228	2.0E-03	pCi/mg	U-236	9.0E-03	pCi/mg
Rn-222	NA	pCi/mg	U-238	6.0E-02	pCi/mg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	4.2E+02	2.8E-11	1.2E-08
Np-237	2.1E+03	2.2E-10	4.6E-07
Pa-231	5.8E+03	9.2E-11	5.3E-07
Pb-210	8.2E+03	6.6E-10	5.4E-06
Pu-238	1.7E+04	2.2E-10	3.7E-06
Pu-239	2.2E+03	2.3E-10	5.1E-07
Pu-240	8.1E+03	2.3E-10	1.9E-06
Ra-226	1.2E+03	1.2E-10	1.5E-07
Ra-228	8.4E+02	1.0E-10	8.4E-08
Rn-222	NA	1.7E-12	NA
Ru-106	5.5E+02	9.5E-12	5.2E-09
Sr-90	2.5E+03	3.6E-11	9.1E-08
Tc-99	1.3E+05	1.3E-12	1.7E-07
Th-228	1.7E+02	5.5E-11	9.2E-09
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	1.2E+06	1.6E-11	1.9E-05
U-235	3.8E+03	1.6E-11	6.0E-08
U-236	3.8E+03	1.5E-11	5.7E-08
U-238	2.5E+04	2.8E-11	7.1E-07
		ILCR Summation =	3.3E-05

Table I.IV-100
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Drinking Water Ingestion

Intake 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 x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/l
4,4-DDE	NA	mg/l
Antimony	1.24E-03	mg/l
Aroclor-1221	2.29E-24	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	NA	mg/l
Aroclor-1260	NA	mg/l
Arsenic	NA	mg/l
Barium	NA	mg/l
Beryllium	NA	mg/l
Boron	NA	mg/l
Cadmium	2.88E-20	mg/l
Carbazole	NA	mg/l
Chromium	NA	mg/l
Cobalt	NA	mg/l
Copper	NA	mg/l

Compound	Concentration	Units
Cyanide	NA	mg/l
Endrin	NA	mg/l
Lead	NA	mg/l
Manganese	NA	mg/l
Mercury	NA	mg/l
Molybdenum	NA	mg/l
Nickel	NA	mg/l
Selenium	NA	mg/l
Silver	NA	mg/l
Tetrachlordibenzo-p-dioxin	NA	mg/l
Thallium	NA	mg/l
Thorium	NA	mg/l
Uranium	NA	mg/l
Vanadium	NA	mg/l
Zinc	NA	mg/l

References

Table I.IV-100
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	7.9E-05	4.0E-04	2.0E-01
Aroclor-1221	1.5E-25	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	NA	3.0E-04	0.0E+00
Barium	NA	7.0E-02	0.0E+00
Beryllium	NA	5.0E-03	0.0E+00
Boron	NA	9.0E-02	0.0E+00
Cadmium	1.8E-21	1.0E-03	1.8E-18
Carbazole	NA	NA	NA
Chromium	NA	5.0E-03	0.0E+00
Cobalt	NA	6.0E-02	0.0E+00
Copper	NA	NA	NA
Cyanide	NA	2.0E-02	0.0E+00
Endrin	NA	3.0E-04	0.0E+00
Lead	NA	NA	NA
Manganese	NA	1.4E-01	0.0E+00
Mercury	NA	3.0E-04	0.0E+00
Molybdenum	NA	5.0E-03	0.0E+00
Nickel	NA	2.0E-02	0.0E+00
Selenium	NA	5.0E-03	0.0E+00
Silver	NA	5.0E-03	0.0E+00
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	NA	8.0E-05	0.0E+00
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	0.0E+00
Vanadium	NA	7.0E-03	0.0E+00
Zinc	NA	3.0E-01	0.0E+00
	HQ Summation =		2.0E-01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	6.8E-06	NA	0.0E+00
Aroclor-1221	1.3E-26	7.7E+00	9.7E-26
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	NA	1.8E+00	NA
Barium	NA	NA	NA
Beryllium	NA	4.3E+00	NA
Boron	NA	NA	NA
Cadmium	1.6E-22	NA	0.0E+00
Carbazole	NA	2.0E-02	NA
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	NA	NA	NA
Cyanide	NA	NA	NA
Endrin	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Molybdenum	NA	NA	NA
Nickel	NA	NA	NA
Selenium	NA	NA	NA
Silver	NA	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	NA	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	NA	NA	NA
	ILCR Summation =		9.7E-26

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Table I.IV-101
Summary of Intake and Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Drinking Water

Intake 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)

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	5.7E-01	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	5.2E+03	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	1.0E+02	pCi/l
Ra-226	NA	pCi/l	U-235	2.7E+00	pCi/l
Ra-228	NA	pCi/l	U-236	1.1E+00	pCi/l
Rn-222	NA	pCi/l	U-238	6.0E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	1.2E+03	2.2E-10	2.6E-07
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	1.1E+07	1.3E-12	1.4E-05
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	2.1E+05	1.6E-11	3.4E-06
U-235	5.6E+03	1.6E-11	9.0E-08
U-236	2.3E+03	1.5E-11	3.5E-08
U-238	1.3E+05	2.8E-11	3.5E-06
		ILCR Summation =	2.2E-05

Table I.IV-102
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Dermal Contact with Soil/Sediment

Intake Equation = $\frac{CS \times EF \times ED \times CF \times ABS \times AF \times SA}{BW \times AT}$

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	Chemical 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 x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	ABS	Concentrati	Units
2-Methylnaphthalene	3.0E-01	NA	mg/kg
4,4-DDE	3.0E-01	NA	mg/kg
Antimony	1.0E-02	2.8E+01	mg/kg
Aroclor-1221	6.0E-02	NA	mg/kg
Aroclor-1248	6.0E-02	NA	mg/kg
Aroclor-1254	6.0E-02	NA	mg/kg
Aroclor-1260	6.0E-02	NA	mg/kg
Arsenic	1.0E-03	9.0E+01	mg/kg
Barium	1.0E-02	4.1E+02	mg/kg
Beryllium	1.0E-02	4.7E+00	mg/kg
Boron	1.0E-02	6.6E+02	mg/kg
Cadmium	1.0E-02	5.9E+00	mg/kg
Carbazole	3.0E-01	NA	mg/kg
Chromium	1.0E-02	4.5E+01	mg/kg
Cobalt	1.0E-02	2.1E+01	mg/kg
Copper	1.0E-03	7.4E+01	mg/kg

Compound		Concentrati	Units
Cyanide	1.0E-02	1.2E+00	mg/kg
Endrin	3.0E-01	NA	mg/kg
Lead	1.0E-02	1.2E+02	mg/kg
Manganese	1.0E-02	2.2E+03	mg/kg
Mercury	5.0E-02	1.1E+00	mg/kg
Molybdenum	1.0E-02	1.3E+01	mg/kg
Nickel	5.0E-04	4.0E+01	mg/kg
Selenium	1.0E-02	5.9E+00	mg/kg
Silver	1.0E-02	1.7E+01	mg/kg
Tetrachlordibenzo-p-dioxin	3.0E-02	5.6E-06	mg/kg
Thallium	1.0E-02	2.7E+00	mg/kg
Thorium	1.0E-02	NA	mg/kg
Uranium	1.0E-02	NA	mg/kg
Vanadium	1.0E-03	5.0E+01	mg/kg
Zinc	1.0E-02	3.5E+02	mg/kg

References

Table I.IV-102 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Dermal Contact with Soil/Sediment

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	3.6E-05	6.0E-05	6.0E-01
Aroclor-1221	NA	5.3E-05	NA
Aroclor-1248	NA	5.3E-05	NA
Aroclor-1254	NA	5.3E-05	NA
Aroclor-1260	NA	5.3E-05	NA
Arsenic	1.1E-05	2.9E-04	4.0E-02
Barium	5.2E-04	6.4E-02	8.2E-03
Beryllium	6.0E-06	5.0E-05	1.2E-01
Boron	8.4E-04	4.5E-03	1.9E-01
Cadmium	7.6E-06	5.0E-05	1.5E-01
Carbazole	NA	NA	NA
Chromium	5.7E-05	2.3E-03	2.5E-02
Cobalt	2.6E-05	2.7E-02	9.8E-04
Copper	9.4E-06	2.2E-02	4.3E-04
Cyanide	1.5E-06	NA	NA
Endrin	NA	2.7E-04	NA
Lead	1.5E-04	NA	NA
Manganese	2.7E-03	4.2E-03	6.5E-01
Mercury	7.0E-06	4.5E-05	1.6E-01
Molybdenum	1.7E-05	1.9E-03	8.8E-03
Nickel	2.6E-06	2.0E-03	1.3E-03
Selenium	7.5E-06	4.0E-03	1.9E-03
Silver	2.2E-05	NA	NA
Tetrachlordibenzo-p-dioxin	2.1E-11	NA	NA
Thallium	3.5E-06	6.0E-05	5.8E-02
Thorium	NA	NA	NA
Uranium	NA	1.5E-04	NA
Vanadium	6.4E-06	3.5E-04	1.8E-02
Zinc	4.5E-04	7.5E-02	6.0E-03
	HQ Summation =		2.0E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.8E-01	NA
Antimony	3.1E-06	NA	NA
Aroclor-1221	NA	1.0E+01	NA
Aroclor-1248	NA	1.0E+01	NA
Aroclor-1254	NA	1.0E+01	NA
Aroclor-1260	NA	1.0E+01	NA
Arsenic	9.8E-07	1.9E+00	1.9E-06
Barium	4.5E-05	NA	NA
Beryllium	5.2E-07	4.3E+02	2.2E-04
Boron	7.2E-05	NA	NA
Cadmium	6.5E-07	NA	NA
Carbazole	NA	2.2E-02	NA
Chromium	4.9E-06	NA	NA
Cobalt	2.3E-06	NA	NA
Copper	8.1E-07	NA	NA
Cyanide	1.3E-07	NA	NA
Endrin	NA	NA	NA
Lead	1.3E-05	NA	NA
Manganese	2.4E-04	NA	NA
Mercury	6.0E-07	NA	NA
Molybdenum	1.4E-06	NA	NA
Nickel	2.2E-07	NA	NA
Selenium	6.5E-07	NA	NA
Silver	1.9E-06	NA	NA
Tetrachlordibenzo-p-dioxin	1.8E-12	3.0E+05	5.5E-07
Thallium	3.0E-07	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	5.5E-07	NA	NA
Zinc	3.9E-05	NA	NA
	ILCR Summation =		2.2E-04

Table I.IV–103
Summary of Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via External Radiation

Exposure Equation = $[CR \times EF \times EDn \times ET_i \times (1-SH_i)] + [CR \times EF \times EDn \times ET_o \times (1-SH_o)]$

EF	Fraction of year spent exposured	0.95 (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	0 (unitless)
CR	Radionuclide specific concentrations	(see table below)

Cs–137	1.0E+00	pCi/g	Ru–106	1.3E+00	pCi/g
Np–237	5.0E+00	pCi/g	Sr–90	6.1E+00	pCi/g
Pa–231	1.4E+01	pCi/g	Tc–99	3.2E+02	pCi/g
Pb–210	2.0E+01	pCi/g	Th–228	4.0E–01	pCi/g
Pu–238	4.0E+01	pCi/g	Th–230	NA	pCi/g
Pu–239	5.3E+00	pCi/g	Th–232	NA	pCi/g
Pu–240	1.9E+01	pCi/g	U–234	2.9E+03	pCi/g
Ra–226	2.9E+00	pCi/g	U–235	9.0E+00	pCi/g
Ra–228	2.0E+00	pCi/g	U–236	9.0E+00	pCi/g
Rn–222	NA	pCi/g	U–238	6.0E+01	pCi/g

Radionuclides	CDI (year pCi/g)	CSF $(g/pCi-year)^{-1}$	ILCR (unitless)
Cs–137	3.1E+00	2.0E–06	6.2E–06
Np–237	1.5E+01	4.3E–07	6.6E–06
Pa–231	4.2E+01	2.6E–08	1.1E–06
Pb–210	6.0E+01	1.6E–10	9.7E–09
Pu–238	1.2E+02	2.8E–11	3.4E–09
Pu–239	1.6E+01	1.7E–11	2.8E–10
Pu–240	5.9E+01	2.7E–11	1.6E–09
Ra–226	9.0E+00	6.0E–06	5.4E–05
Ra–228	6.2E+00	2.9E–06	1.8E–05
Rn–222	NA	5.9E–06	NA
Ru–106	4.0E+00	NA	NA
Sr–90	1.9E+01	NA	NA
Tc–99	9.8E+02	6.0E–13	5.9E–10
Th–228	1.2E+00	5.6E–06	6.9E–06
Th–230	NA	5.4E–11	NA
Th–232	NA	2.6E–11	NA
U–234	8.9E+03	3.0E–11	2.7E–07
U–235	2.8E+01	2.4E–07	6.6E–06
U–236	2.8E+01	2.4E–11	6.6E–10
U–238	1.8E+02	3.6E–08	6.6E–06
		ILCR Summation =	1.1E–04

Table I.IV-104
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
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	0.029 kg/day
FI	Fraction ingested from contaminated source	1 (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 x 365)	2190 days
CS	Concentration of chemicals in meat	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	0.0E+00	mg/kg
4,4-DDE	5.9E-04	mg/kg
Antimony	1.1E-02	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	7.5E-03	mg/kg
Aroclor-1260	9.6E-03	mg/kg
Arsenic	2.5E-02	mg/kg
Barium	1.2E-01	mg/kg
Beryllium	7.6E-04	mg/kg
Boron	1.8E+01	mg/kg
Cadmium	5.4E-02	mg/kg
Carbazole	0.0E+00	mg/kg
Chromium	7.9E-02	mg/kg
Cobalt	3.6E-01	mg/kg
Copper	4.1E+00	mg/kg
Cyanide	2.5E-07	mg/kg
Endrin	3.1E-06	mg/kg
Lead	1.9E-02	mg/kg
Manganese	5.1E+00	mg/kg
Mercury	2.4E+00	mg/kg
Molybdenum	1.4E-01	mg/kg
Nickel	4.7E-01	mg/kg
Selenium	1.7E-02	mg/kg
Silver	3.7E-01	mg/kg
Tetrachlordibenzo-p-dioxin	0.0E+00	mg/kg
Thallium	1.6E-02	mg/kg
Thorium	0.0E+00	mg/kg
Uranium	1.2E-07	mg/kg
Vanadium	5.0E-02	mg/kg
Zinc	4.8E+02	mg/kg

References

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Table I.IV-104 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	1.1E-06	NA	NA
Antimony	2.0E-05	4.0E-04	5.0E-02
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.4E-05	NA	NA
Aroclor-1260	1.8E-05	NA	NA
Arsenic	4.7E-05	3.0E-04	1.6E-01
Barium	2.2E-04	7.0E-02	3.1E-03
Beryllium	1.4E-06	5.0E-03	2.8E-04
Boron	3.3E-02	9.0E-02	3.7E-01
Cadmium	9.9E-05	1.0E-03	9.9E-02
Carbazole	NA	NA	NA
Chromium	1.5E-04	5.0E-03	2.9E-02
Cobalt	6.7E-04	6.0E-02	1.1E-02
Copper	7.7E-03	NA	NA
Cyanide	4.7E-10	2.0E-02	2.3E-08
Endrin	5.8E-09	3.0E-04	1.9E-05
Lead	3.6E-05	NA	NA
Manganese	9.4E-03	1.4E-01	6.7E-02
Mercury	4.5E-03	3.0E-04	1.5E+01
Molybdenum	2.5E-04	5.0E-03	5.1E-02
Nickel	8.8E-04	2.0E-02	4.4E-02
Selenium	3.1E-05	5.0E-03	6.1E-03
Silver	6.9E-04	5.0E-03	1.4E-01
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	2.9E-05	8.0E-05	3.6E-01
Thorium	NA	NA	NA
Uranium	2.3E-10	3.0E-03	7.5E-08
Vanadium	9.3E-05	7.0E-03	1.3E-02
Zinc	9.0E-01	3.0E-01	3.0E+00
	HQ Summation =		1.9E+01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	9.4E-08	3.4E-01	3.2E-08
Antimony	1.7E-06	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.2E-06	7.7E+00	9.2E-06
Aroclor-1260	1.5E-06	7.7E+00	1.2E-05
Arsenic	4.0E-06	1.8E+00	7.3E-06
Barium	1.9E-05	NA	NA
Beryllium	1.2E-07	4.3E+00	5.2E-07
Boron	2.9E-03	NA	NA
Cadmium	8.5E-06	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	1.3E-05	NA	NA
Cobalt	5.8E-05	NA	NA
Copper	6.6E-04	NA	NA
Cyanide	4.0E-11	NA	NA
Endrin	4.9E-10	NA	NA
Lead	3.1E-06	NA	NA
Manganese	8.1E-04	NA	NA
Mercury	3.9E-04	NA	NA
Molybdenum	2.2E-05	NA	NA
Nickel	7.5E-05	NA	NA
Selenium	2.6E-06	NA	NA
Silver	5.9E-05	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	2.5E-06	NA	NA
Thorium	NA	NA	NA
Uranium	1.9E-11	NA	NA
Vanadium	8.0E-06	NA	NA
Zinc	7.7E-02	NA	NA
	ILCR Summation =		2.9E-05

Table I.IV-105
Summary of Intake and Risk Quantitation (Radionuclides)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.029 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Cs-137	5.26E+01	pCi/kg	Ru-106	0.00E+00	pCi/kg
Np-237	6.16E-03	pCi/kg	Sr-90	1.25E-01	pCi/kg
Pa-231	1.7E-05	pCi/kg	Tc-99	7.95E+00	pCi/kg
Pb-210	0.0E+00	pCi/kg	Th-228	1.21E-03	pCi/kg
Pu-238	2.4E-05	pCi/kg	Th-230	3.29E-04	pCi/kg
Pu-239	3.3E-06	pCi/kg	Th-232	6.93E-03	pCi/kg
Pu-240	1.2E-05	pCi/kg	U-234	4.82E+00	pCi/kg
Ra-226	9.6E-02	pCi/kg	U-235	2.00E-01	pCi/kg
Ra-228	1.7E-01	pCi/kg	U-236	1.28E+00	pCi/kg
Rn-222	0.0E+00	pCi/kg	U-238	3.15E+00	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	3.2E+03	2.8E-11	9.0E-08
Np-237	3.8E-01	2.2E-10	8.3E-11
Pa-231	1.0E-03	9.2E-11	9.3E-14
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	1.4E-03	2.2E-10	3.2E-13
Pu-239	2.0E-04	2.3E-10	4.6E-14
Pu-240	7.2E-04	2.3E-10	1.7E-13
Ra-226	5.9E+00	1.2E-10	7.0E-10
Ra-228	1.0E+01	1.0E-10	1.0E-09
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	0.0E+00	9.5E-12	NA
Sr-90	7.6E+00	3.6E-11	2.7E-10
Tc-99	4.8E+02	1.3E-12	6.3E-10
Th-228	7.4E-02	5.5E-11	4.1E-12
Th-230	2.0E-02	1.3E-11	2.6E-13
Th-232	4.2E-01	1.2E-11	5.1E-12
U-234	2.9E+02	1.6E-11	4.7E-09
U-235	1.2E+01	1.6E-11	1.9E-10
U-236	7.8E+01	1.5E-11	1.2E-09
U-238	1.9E+02	2.8E-11	5.4E-09
		ILCR Summation =	1.0E-07

Table I.IV-106
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
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	0.68 l/day
FI	Fraction ingested from contaminated source	1 (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 x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	0.0E+00	mg/l
4,4-DDE	1.1E-04	mg/l
Antimony	1.1E-03	mg/l
Aroclor-1221	0.0E+00	mg/l
Aroclor-1248	0.0E+00	mg/l
Aroclor-1254	2.4E-03	mg/l
Aroclor-1260	3.0E-03	mg/l
Arsenic	7.6E-04	mg/l
Barium	2.7E-01	mg/l
Beryllium	6.8E-07	mg/l
Boron	3.4E+01	mg/l
Cadmium	9.7E-02	mg/l
Carbazole	0.0E+00	mg/l
Chromium	2.2E-02	mg/l
Cobalt	3.6E-02	mg/l
Copper	6.2E-01	mg/l

Compound	Concentration	Units
Cyanide	8.1E-08	mg/l
Endrin	4.5E-07	mg/l
Lead	1.6E-02	mg/l
Manganese	4.4E+00	mg/l
Mercury	4.4E-03	mg/l
Molybdenum	3.4E-02	mg/l
Nickel	7.9E-02	mg/l
Selenium	4.4E-03	mg/l
Silver	2.5E+00	mg/l
Tetrachlordibenzo-p-dioxin	0.0E+00	mg/l
Thallium	7.8E-04	mg/l
Thorium	0.0E+00	mg/l
Uranium	3.7E-07	mg/l
Vanadium	4.0E-04	mg/l
Zinc	4.8E+01	mg/l

References

Table I.IV-106 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	5.0E-06	NA	NA
Antimony	4.7E-05	4.0E-04	1.2E-01
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.0E-04	NA	NA
Aroclor-1260	1.3E-04	NA	NA
Arsenic	3.3E-05	3.0E-04	1.1E-01
Barium	1.2E-02	7.0E-02	1.7E-01
Beryllium	3.0E-08	5.0E-03	5.9E-06
Boron	1.5E+00	9.0E-02	1.6E+01
Cadmium	4.2E-03	1.0E-03	4.2E+00
Carbazole	NA	NA	NA
Chromium	9.4E-04	5.0E-03	1.9E-01
Cobalt	1.6E-03	6.0E-02	2.6E-02
Copper	2.7E-02	NA	NA
Cyanide	3.5E-09	2.0E-02	1.8E-07
Endrin	2.0E-08	3.0E-04	6.5E-05
Lead	7.0E-04	NA	NA
Manganese	1.9E-01	1.4E-01	1.4E+00
Mercury	1.9E-04	3.0E-04	6.3E-01
Molybdenum	1.5E-03	5.0E-03	3.0E-01
Nickel	3.4E-03	2.0E-02	1.7E-01
Selenium	1.9E-04	5.0E-03	3.8E-02
Silver	1.1E-01	5.0E-03	2.1E+01
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	3.4E-05	8.0E-05	4.2E-01
Thorium	NA	NA	NA
Uranium	1.6E-08	3.0E-03	5.3E-06
Vanadium	1.8E-05	7.0E-03	2.5E-03
Zinc	2.1E+00	3.0E-01	7.0E+00
	HQ Summation =		5.3E+01

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.3E-07	3.4E-01	1.5E-07
Antimony	4.0E-06	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	8.9E-06	7.7E+00	6.8E-05
Aroclor-1260	1.1E-05	7.7E+00	8.7E-05
Arsenic	2.8E-06	1.8E+00	5.1E-06
Barium	1.0E-03	NA	NA
Beryllium	2.5E-09	4.3E+00	1.1E-08
Boron	1.3E-01	NA	NA
Cadmium	3.6E-04	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	8.0E-05	NA	NA
Cobalt	1.4E-04	NA	NA
Copper	2.3E-03	NA	NA
Cyanide	3.0E-10	NA	NA
Endrin	1.7E-09	NA	NA
Lead	6.0E-05	NA	NA
Manganese	1.7E-02	NA	NA
Mercury	1.6E-05	NA	NA
Molybdenum	1.3E-04	NA	NA
Nickel	2.9E-04	NA	NA
Selenium	1.6E-05	NA	NA
Silver	9.2E-03	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	2.9E-06	NA	NA
Thorium	NA	NA	NA
Uranium	1.4E-09	NA	NA
Vanadium	1.5E-06	NA	NA
Zinc	1.8E-01	NA	NA
	ILCR Summation =		1.6E-04

Table I.IV–107
Summary of Intake and Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.68 l/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Cs-137	1.84E+01	pCi/l	Ru-106	1.79E-25	pCi/l
Np-237	5.88E-04	pCi/l	Sr-90	2.23E-19	pCi/l
Pa-231	1.0E-07	pCi/l	Tc-99	1.72E-17	pCi/l
Pb-210	0.0E+00	pCi/l	Th-228	9.65E-04	pCi/l
Pu-238	4.7E-06	pCi/l	Th-230	2.74E-04	pCi/l
Pu-239	6.5E-07	pCi/l	Th-232	5.87E-03	pCi/l
Pu-240	2.4E-06	pCi/l	U-234	1.51E+01	pCi/l
Ra-226	2.1E-01	pCi/l	U-235	6.15E-01	pCi/l
Ra-228	3.8E-01	pCi/l	U-236	3.85E+00	pCi/l
Rn-222	0.0E+00	pCi/l	U-238	9.82E+00	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	2.6E+04	2.8E-11	7.4E-07
Np-237	8.4E-01	2.2E-10	1.8E-10
Pa-231	1.5E-04	9.2E-11	1.4E-14
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	6.8E-03	2.2E-10	1.5E-12
Pu-239	9.3E-04	2.3E-10	2.1E-13
Pu-240	3.4E-03	2.3E-10	7.8E-13
Ra-226	3.1E+02	1.2E-10	3.7E-08
Ra-228	5.4E+02	1.0E-10	5.4E-08
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	2.6E-22	9.5E-12	2.4E-33
Sr-90	3.2E-16	3.6E-11	1.1E-26
Tc-99	2.4E-14	1.3E-12	3.2E-26
Th-228	1.4E+00	5.5E-11	7.6E-11
Th-230	3.9E-01	1.3E-11	5.1E-12
Th-232	8.4E+00	1.2E-11	1.0E-10
U-234	2.2E+04	1.6E-11	3.4E-07
U-235	8.8E+02	1.6E-11	1.4E-08
U-236	5.5E+03	1.5E-11	8.2E-08
U-238	1.4E+04	2.8E-11	3.9E-07
		ILCR Summation =	1.7E-06

Table I.IV-108
Summary of Intake Quantitation (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
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	0.106 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 x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	5.3E-10	mg/kg
4,4-DDE	3.9E-04	mg/kg
Antimony	6.8E-02	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	2.4E-03	mg/kg
Aroclor-1260	1.4E-03	mg/kg
Arsenic	1.3E-02	mg/kg
Barium	6.2E-01	mg/kg
Beryllium	3.2E-03	mg/kg
Boron	9.6E+01	mg/kg
Cadmium	2.2E-01	mg/kg
Carbazole	1.0E-09	mg/kg
Chromium	3.2E-02	mg/kg
Cobalt	3.6E-02	mg/kg
Copper	2.2E+00	mg/kg

Compound	Concentration	Units
Cyanide	3.1E-09	mg/kg
Endrin	1.3E-06	mg/kg
Lead	9.0E-02	mg/kg
Manganese	2.1E+01	mg/kg
Mercury	1.8E-02	mg/kg
Molybdenum	1.7E+00	mg/kg
Nickel	5.8E-01	mg/kg
Selenium	6.8E-03	mg/kg
Silver	2.6E-01	mg/kg
Tetrachlordibenzo-p-dioxin	2.8E-15	mg/kg
Thallium	9.5E-05	mg/kg
Thorium	3.1E-07	mg/kg
Uranium	7.9E-06	mg/kg
Vanadium	3.3E-02	mg/kg
Zinc	2.5E+01	mg/kg

References

Table I.IV-108 (continued)
Summary of Risk Characterization (chemicals)
On-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Vegetables and Fruits

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	1.8E-12	NA	NA
4,4-DDE	1.3E-06	NA	NA
Antimony	2.3E-04	4.0E-04	5.8E-01
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	8.1E-06	NA	NA
Aroclor-1260	4.7E-06	NA	NA
Arsenic	4.4E-05	3.0E-04	1.5E-01
Barium	2.1E-03	7.0E-02	3.0E-02
Beryllium	1.1E-05	5.0E-03	2.2E-03
Boron	3.2E-01	9.0E-02	3.6E+00
Cadmium	7.6E-04	1.0E-03	7.6E-01
Carbazole	3.4E-12	NA	NA
Chromium	1.1E-04	5.0E-03	2.1E-02
Cobalt	1.2E-04	6.0E-02	2.0E-03
Copper	7.3E-03	NA	NA
Cyanide	1.1E-11	2.0E-02	5.3E-10
Endrin	4.5E-09	3.0E-04	1.5E-05
Lead	3.1E-04	NA	NA
Manganese	7.1E-02	1.4E-01	5.1E-01
Mercury	6.2E-05	3.0E-04	2.1E-01
Molybdenum	5.7E-03	5.0E-03	1.1E+00
Nickel	2.0E-03	2.0E-02	9.8E-02
Selenium	2.3E-05	5.0E-03	4.6E-03
Silver	8.7E-04	5.0E-03	1.7E-01
Tetrachlordibenzo-p-dioxin	9.5E-18	NA	NA
Thallium	3.2E-07	8.0E-05	4.0E-03
Thorium	1.1E-09	NA	NA
Uranium	2.7E-08	3.0E-03	9.0E-06
Vanadium	1.1E-04	7.0E-03	1.6E-02
Zinc	8.4E-02	3.0E-01	2.8E-01
	HQ Summation =		7.6E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	1.5E-13	NA	NA
4,4-DDE	1.1E-07	3.4E-01	3.8E-08
Antimony	2.0E-05	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	6.9E-07	7.7E+00	5.3E-06
Aroclor-1260	4.0E-07	7.7E+00	3.1E-06
Arsenic	3.8E-06	1.8E+00	6.8E-06
Barium	1.8E-04	NA	NA
Beryllium	9.4E-07	4.3E+00	4.0E-06
Boron	2.8E-02	NA	NA
Cadmium	6.5E-05	NA	NA
Carbazole	2.9E-13	2.0E-02	5.8E-15
Chromium	9.2E-06	NA	NA
Cobalt	1.1E-05	NA	NA
Copper	6.3E-04	NA	NA
Cyanide	9.0E-13	NA	NA
Endrin	3.9E-10	NA	NA
Lead	2.6E-05	NA	NA
Manganese	6.1E-03	NA	NA
Mercury	5.3E-06	NA	NA
Molybdenum	4.8E-04	NA	NA
Nickel	1.7E-04	NA	NA
Selenium	2.0E-06	NA	NA
Silver	7.5E-05	NA	NA
Tetrachlordibenzo-p-dioxin	8.1E-19	1.5E+05	1.2E-13
Thallium	2.8E-08	NA	NA
Thorium	9.1E-11	NA	NA
Uranium	2.3E-09	NA	NA
Vanadium	9.7E-06	NA	NA
Zinc	7.2E-03	NA	NA
	ILCR Summation =		1.9E-05

Table I.IV–109
Summary of Intake and Risk Quantitation (Radionuclides)
On–Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.106 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	

Cs-137	7.49E+00	pCi/kg	Ru-106	4.40E-11	pCi/kg
Np-237	3.58E-01	pCi/kg	Sr-90	3.36E-09	pCi/kg
Pa-231	2.7E-06	pCi/kg	Tc-99	1.01E-06	pCi/kg
Pb-210	4.0E+00	pCi/kg	Th-228	1.42E-02	pCi/kg
Pu-238	1.8E-03	pCi/kg	Th-230	2.19E-03	pCi/kg
Pu-239	2.4E-04	pCi/kg	Th-232	2.17E-02	pCi/kg
Pu-240	8.8E-04	pCi/kg	U-234	5.29E+02	pCi/kg
Ra-226	2.5E-01	pCi/kg	U-235	1.47E+01	pCi/kg
Ra-228	4.4E-01	pCi/kg	U-236	1.72E+01	pCi/kg
Rn-222	3.6E-01	pCi/kg	U-238	3.17E+02	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	8.3E+02	2.8E-11	2.3E-08
Np-237	4.0E+01	2.2E-10	8.8E-09
Pa-231	3.0E-04	9.2E-11	2.8E-14
Pb-210	4.5E+02	6.6E-10	3.0E-07
Pu-238	2.0E-01	2.2E-10	4.3E-11
Pu-239	2.7E-02	2.3E-10	6.2E-12
Pu-240	9.8E-02	2.3E-10	2.3E-11
Ra-226	2.8E+01	1.2E-10	3.3E-09
Ra-228	4.9E+01	1.0E-10	4.9E-09
Rn-222	4.0E+01	1.7E-12	6.8E-11
Ru-106	4.9E-09	9.5E-12	4.7E-20
Sr-90	3.7E-07	3.6E-11	1.3E-17
Tc-99	1.1E-04	1.3E-12	1.5E-16
Th-228	1.6E+00	5.5E-11	8.7E-11
Th-230	2.4E-01	1.3E-11	3.2E-12
Th-232	2.4E+00	1.2E-11	2.9E-11
U-234	5.9E+04	1.6E-11	9.4E-07
U-235	1.6E+03	1.6E-11	2.6E-08
U-236	1.9E+03	1.5E-11	2.9E-08
U-238	3.5E+04	2.8E-11	9.9E-07
		ILCR Summation =	2.3E-06

Table I.IV-110
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Intake 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 x 365)	25550 days
CS	Concentration of chemicals in particulate as modeled	(see table below)

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3	Cyanide	2.3E-08	mg/m^3
4,4-DDE	1.0E-09	mg/m^3	Endrin	1.5E-10	mg/m^3
Antimony	5.5E-07	mg/m^3	Lead	2.1E-06	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3	Manganese	7.7E-05	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3	Mercury	2.8E-08	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3	Molybdenum	5.4E-07	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3	Nickel	1.8E-06	mg/m^3
Arsenic	5.3E-07	mg/m^3	Selenium	6.5E-08	mg/m^3
Barium	8.7E-06	mg/m^3	Silver	6.5E-07	mg/m^3
Beryllium	6.0E-08	mg/m^3	Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Boron	1.1E-05	mg/m^3	Thallium	4.4E-08	mg/m^3
Cadmium	3.7E-07	mg/m^3	Thorium	2.3E-06	mg/m^3
Carbazole	7.3E-09	mg/m^3	Uranium	5.8E-05	mg/m^3
Chromium	1.2E-06	mg/m^3	Vanadium	2.1E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3	Zinc	6.3E-06	mg/m^3
Copper	2.0E-06	mg/m^3			

References

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Table I.IV-110 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	1.1E-09	NA	NA
4,4-DDE	2.8E-10	NA	NA
Antimony	1.5E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.4E-09	NA	NA
Aroclor-1260	5.3E-09	NA	NA
Arsenic	1.5E-07	NA	NA
Barium	2.4E-06	1.0E-04	2.4E-02
Beryllium	1.6E-08	NA	NA
Boron	3.0E-06	5.7E-03	5.3E-04
Cadmium	1.0E-07	NA	NA
Carbazole	2.0E-09	NA	NA
Chromium	3.3E-07	NA	NA
Cobalt	2.6E-07	3.0E-07	8.5E-01
Copper	5.6E-07	NA	NA
Cyanide	6.3E-09	NA	NA
Endrin	4.0E-11	NA	NA
Lead	5.8E-07	NA	NA
Manganese	2.1E-05	1.1E-04	1.9E-01
Mercury	7.6E-09	8.6E-05	8.8E-05
Molybdenum	1.5E-07	NA	NA
Nickel	4.9E-07	NA	NA
Selenium	1.8E-08	NA	NA
Silver	1.8E-07	NA	NA
Tetrachlordibenzo-p-dioxin	5.6E-15	NA	NA
Thallium	1.2E-08	NA	NA
Thorium	6.3E-07	NA	NA
Uranium	1.6E-05	NA	NA
Vanadium	5.8E-07	NA	NA
Zinc	1.7E-06	NA	NA
	HQ Summation =		1.1E+00

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	1.1E-09	NA	NA
4,4-DDE	2.8E-10	NA	NA
Antimony	1.5E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.4E-09	NA	NA
Aroclor-1260	5.3E-09	NA	NA
Arsenic	1.5E-07	1.5E+01	2.2E-06
Barium	2.4E-06	NA	NA
Beryllium	1.6E-08	8.4E+00	1.4E-07
Boron	3.0E-06	NA	NA
Cadmium	1.0E-07	6.1E+00	6.3E-07
Carbazole	2.0E-09	NA	NA
Chromium	3.3E-07	4.1E+01	1.4E-05
Cobalt	2.6E-07	NA	NA
Copper	5.6E-07	NA	NA
Cyanide	6.3E-09	NA	NA
Endrin	4.0E-11	NA	NA
Lead	5.8E-07	NA	NA
Manganese	2.1E-05	NA	NA
Mercury	7.6E-09	NA	NA
Molybdenum	1.5E-07	NA	NA
Nickel	4.9E-07	8.4E-01	4.1E-07
Selenium	1.8E-08	NA	NA
Silver	1.8E-07	NA	NA
Tetrachlordibenzo-p-dioxin	5.6E-15	1.5E+05	8.5E-10
Thallium	1.2E-08	NA	NA
Thorium	6.3E-07	NA	NA
Uranium	1.6E-05	NA	NA
Vanadium	5.8E-07	NA	NA
Zinc	1.7E-06	NA	NA
	ILCR Summation =		1.7E-05

Table I.IV–111
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Inhalation of Gases and Particulates

Intake 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)

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	2.3E+01	1.9E-11	4.4E-10
Np-237	9.6E+00	2.9E-08	2.8E-07
Pa-231	9.8E+00	3.6E-08	3.5E-07
Pb-210	4.1E+01	4.0E-09	1.6E-07
Pu-238	1.5E+01	3.9E-08	5.8E-07
Pu-239	3.7E+00	3.8E-08	1.4E-07
Pu-240	1.4E+01	3.8E-08	5.1E-07
Ra-226	1.5E+01	3.0E-09	4.6E-08
Ra-228	2.7E+01	6.9E-10	1.9E-08
Rn-222	1.3E+06	7.7E-12	1.0E-05
Ru-106	4.1E+00	4.4E-10	1.8E-09
Sr-90	3.9E+01	6.2E-11	2.4E-09
Tc-99	1.9E+02	8.3E-12	1.6E-09
Th-228	1.8E+01	7.8E-08	1.4E-06
Th-230	1.3E+02	2.9E-08	3.7E-06
Th-232	4.6E+01	2.8E-08	1.3E-06
U-234	1.2E+03	2.6E-08	3.0E-05
U-235	4.8E+01	2.5E-08	1.2E-06
U-236	2.8E+02	2.5E-08	7.1E-06
U-238	5.9E+02	5.2E-11	3.1E-08
		ILCR Summation =	5.7E-05

Table I.IV-112
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
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
2-Methylnaphthalene	NA	mg/l
4,4-DDE	NA	mg/l
Antimony	6.90E-08	mg/l
Aroclor-1221	1.03E-27	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	NA	mg/l
Aroclor-1260	NA	mg/l
Arsenic	NA	mg/l
Barium	NA	mg/l
Beryllium	NA	mg/l
Boron	NA	mg/l
Cadmium	1.71E-24	mg/l
Carbazole	NA	mg/l
Chromium	NA	mg/l
Cobalt	NA	mg/l
Copper	NA	mg/l

Compound	Concentration	Units
Cyanide	NA	mg/l
Endrin	NA	mg/l
Lead	NA	mg/l
Manganese	NA	mg/l
Mercury	NA	mg/l
Molybdenum	NA	mg/l
Nickel	NA	mg/l
Selenium	NA	mg/l
Silver	NA	mg/l
Tetrachlordibenzo-p-dioxin	NA	mg/l
Thallium	NA	mg/l
Thorium	NA	mg/l
Uranium	NA	mg/l
Vanadium	NA	mg/l
Zinc	NA	mg/l

References

Table I.IV-112
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Drinking Water Ingestion

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	1.9E-09	4.0E-04	4.7E-06
Aroclor-1221	2.8E-29	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	NA	3.0E-04	0.0E+00
Barium	NA	7.0E-02	0.0E+00
Beryllium	NA	5.0E-03	0.0E+00
Boron	NA	9.0E-02	0.0E+00
Cadmium	4.7E-26	1.0E-03	4.7E-23
Carbazole	NA	NA	NA
Chromium	NA	5.0E-03	0.0E+00
Cobalt	NA	6.0E-02	0.0E+00
Copper	NA	NA	NA
Cyanide	NA	2.0E-02	0.0E+00
Endrin	NA	3.0E-04	0.0E+00
Lead	NA	NA	NA
Manganese	NA	1.4E-01	0.0E+00
Mercury	NA	3.0E-04	0.0E+00
Molybdenum	NA	5.0E-03	0.0E+00
Nickel	NA	2.0E-02	0.0E+00
Selenium	NA	5.0E-03	0.0E+00
Silver	NA	5.0E-03	0.0E+00
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	NA	8.0E-05	0.0E+00
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	0.0E+00
Vanadium	NA	7.0E-03	0.0E+00
Zinc	NA	3.0E-01	0.0E+00
	HQ Summation =		4.7E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	1.9E-09	NA	0.0E+00
Aroclor-1221	2.8E-29	7.7E+00	2.2E-28
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	NA	1.8E+00	NA
Barium	NA	NA	NA
Beryllium	NA	4.3E+00	NA
Boron	NA	NA	NA
Cadmium	4.7E-26	NA	0.0E+00
Carbazole	NA	2.0E-02	NA
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	NA	NA	NA
Cyanide	NA	NA	NA
Endrin	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Molybdenum	NA	NA	NA
Nickel	NA	NA	NA
Selenium	NA	NA	NA
Silver	NA	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	NA	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	NA	NA	NA
	ILCR Summation =		2.2E-28

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Table I.IV-113
Summary of Intake and Risk Quantitation (Radionuclides)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
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)

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	8.0E-02	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	1.2E+03	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	2.6E+01	pCi/l
Ra-226	NA	pCi/l	U-235	7.0E-01	pCi/l
Ra-228	NA	pCi/l	U-236	2.9E-01	pCi/l
Rn-222	NA	pCi/l	U-238	1.6E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	3.9E+03	2.2E-10	8.7E-07
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	6.0E+07	1.3E-12	7.8E-05
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	1.3E+06	1.6E-11	2.1E-05
U-235	3.4E+04	1.6E-11	5.5E-07
U-236	1.4E+04	1.5E-11	2.1E-07
U-238	7.7E+05	2.8E-11	2.2E-05

ILCR Summation = 1.2E-04

Table I.IV-114
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
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	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (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 fish	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	0.0E+00	mg/kg
4,4-DDE	5.3E-10	mg/kg
Antimony	9.2E-09	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	9.6E-09	mg/kg
Aroclor-1260	6.5E-09	mg/kg
Arsenic	1.1E-08	mg/kg
Barium	1.4E-08	mg/kg
Beryllium	6.2E-10	mg/kg
Boron	1.1E-07	mg/kg
Cadmium	2.4E-09	mg/kg
Carbazole	0.0E+00	mg/kg
Chromium	7.0E-08	mg/kg
Cobalt	1.9E-07	mg/kg
Copper	2.2E-07	mg/kg

Compound	Concentration	Units
Cyanide	1.4E-14	mg/kg
Endrin	1.8E-11	mg/kg
Lead	6.7E-09	mg/kg
Manganese	3.2E-07	mg/kg
Mercury	7.6E-08	mg/kg
Molybdenum	3.4E-08	mg/kg
Nickel	1.1E-07	mg/kg
Selenium	1.0E-08	mg/kg
Silver	2.1E-08	mg/kg
Tetrachlordibenzo-p-dioxin	0.0E+00	mg/kg
Thallium	1.8E-08	mg/kg
Thorium	0.0E+00	mg/kg
Uranium	1.2E-07	mg/kg
Vanadium	5.5E-08	mg/kg
Zinc	9.0E-06	mg/kg

References

Table I.IV-114 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	5.4E-13	NA	NA
Antimony	9.4E-12	4.0E-04	2.4E-08
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	9.9E-12	NA	NA
Aroclor-1260	6.7E-12	NA	NA
Arsenic	1.2E-11	3.0E-04	3.9E-08
Barium	1.5E-11	7.0E-02	2.1E-10
Beryllium	6.4E-13	5.0E-03	1.3E-10
Boron	1.2E-10	9.0E-02	1.3E-09
Cadmium	2.5E-12	1.0E-03	2.5E-09
Carbazole	NA	NA	NA
Chromium	7.2E-11	5.0E-03	1.4E-08
Cobalt	2.0E-10	6.0E-02	3.3E-09
Copper	2.2E-10	NA	NA
Cyanide	1.4E-17	2.0E-02	7.0E-16
Endrin	1.9E-14	3.0E-04	6.3E-11
Lead	6.8E-12	NA	NA
Manganese	3.3E-10	1.4E-01	2.4E-09
Mercury	7.8E-11	3.0E-04	2.6E-07
Molybdenum	3.5E-11	5.0E-03	7.1E-09
Nickel	1.2E-10	2.0E-02	5.8E-09
Selenium	1.1E-11	5.0E-03	2.1E-09
Silver	2.1E-11	5.0E-03	4.2E-09
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	1.9E-11	8.0E-05	2.4E-07
Thorium	NA	NA	NA
Uranium	1.3E-10	3.0E-03	4.2E-08
Vanadium	5.7E-11	7.0E-03	8.1E-09
Zinc	9.3E-09	3.0E-01	3.1E-08
	HQ Summation =		6.8E-07

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	5.4E-13	3.4E-01	1.8E-13
Antimony	9.4E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	9.9E-12	7.7E+00	7.6E-11
Aroclor-1260	6.7E-12	7.7E+00	5.2E-11
Arsenic	1.2E-11	1.8E+00	2.1E-11
Barium	1.5E-11	NA	NA
Beryllium	6.4E-13	4.3E+00	2.8E-12
Boron	1.2E-10	NA	NA
Cadmium	2.5E-12	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	7.2E-11	NA	NA
Cobalt	2.0E-10	NA	NA
Copper	2.2E-10	NA	NA
Cyanide	1.4E-17	NA	NA
Endrin	1.9E-14	NA	NA
Lead	6.8E-12	NA	NA
Manganese	3.3E-10	NA	NA
Mercury	7.8E-11	NA	NA
Molybdenum	3.5E-11	NA	NA
Nickel	1.2E-10	NA	NA
Selenium	1.1E-11	NA	NA
Silver	2.1E-11	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	1.9E-11	NA	NA
Thorium	NA	NA	NA
Uranium	1.3E-10	NA	NA
Vanadium	5.7E-11	NA	NA
Zinc	9.3E-09	NA	NA
	ILCR Summation =		1.5E-10

Table I.IV–115
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.075 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cf	Concentration of radionuclides in fish	

Cs-137	1.01E-05	pCi/kg	Ru-106	0.00E+00	pCi/kg
Np-237	2.21E-04	pCi/kg	Sr-90	NA	pCi/kg
Pa-231	1.7E-05	pCi/kg	Tc-99	NA	pCi/kg
Pb-210	0.0E+00	pCi/kg	Th-228	1.39E-09	pCi/kg
Pu-238	1.6E-10	pCi/kg	Th-230	1.62E-08	pCi/kg
Pu-239	4.0E-11	pCi/kg	Th-232	5.88E-09	pCi/kg
Pu-240	1.4E-10	pCi/kg	U-234	2.62E-01	pCi/kg
Ra-226	5.1E-08	pCi/kg	U-235	6.96E-03	pCi/kg
Ra-228	8.9E-08	pCi/kg	U-236	2.87E-03	pCi/kg
Rn-222	0.0E+00	pCi/kg	U-238	1.57E-01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.9E-02	2.8E-11	5.2E-13
Np-237	4.1E-01	2.2E-10	8.9E-11
Pa-231	3.1E-02	9.2E-11	2.8E-12
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	2.9E-07	2.2E-10	6.4E-17
Pu-239	7.3E-08	2.3E-10	1.7E-17
Pu-240	2.6E-07	2.3E-10	6.1E-17
Ra-226	9.4E-05	1.2E-10	1.1E-14
Ra-228	1.6E-04	1.0E-10	1.6E-14
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	0.0E+00	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	NA	1.3E-12	NA
Th-228	2.6E-06	5.5E-11	1.4E-16
Th-230	3.0E-05	1.3E-11	3.9E-16
Th-232	1.1E-05	1.2E-11	1.3E-16
U-234	4.8E+02	1.6E-11	7.7E-09
U-235	1.3E+01	1.6E-11	2.0E-10
U-236	5.3E+00	1.5E-11	7.9E-11
U-238	2.9E+02	2.8E-11	8.1E-09
		ILCR Summation =	1.6E-08

Table I.IV-116
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Ingestion of Milk Products

Intake Equation = $\frac{CS \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of dairy products	0.3 l/day
FI	Fraction ingested from contaminated source	1 (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
2-Methylnaphthalene	NA	mg/l
4,4-DDE	1.0E-10	mg/l
Antimony	9.9E-10	mg/l
Aroclor-1221	NA	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	3.0E-09	mg/l
Aroclor-1260	2.1E-09	mg/l
Arsenic	3.4E-10	mg/l
Barium	3.3E-08	mg/l
Beryllium	5.6E-13	mg/l
Boron	2.1E-07	mg/l
Cadmium	4.4E-09	mg/l
Carbazole	NA	mg/l
Chromium	1.9E-08	mg/l
Cobalt	1.9E-08	mg/l
Copper	3.3E-08	mg/l

Compound	Concentration	Units
Cyanide	4.4E-15	mg/l
Endrin	2.7E-12	mg/l
Lead	5.5E-09	mg/l
Manganese	2.8E-07	mg/l
Mercury	1.4E-10	mg/l
Molybdenum	8.6E-09	mg/l
Nickel	1.9E-08	mg/l
Selenium	2.7E-09	mg/l
Silver	1.4E-07	mg/l
Tetrachlordibenzo-p-dioxin	NA	mg/l
Thallium	9.2E-10	mg/l
Thorium	NA	mg/l
Uranium	3.7E-07	mg/l
Vanadium	4.4E-10	mg/l
Zinc	9.0E-07	mg/l

References

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Table I.IV-116 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Ingestion of Milk Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.2E-13	NA	NA
Antimony	4.1E-12	4.0E-04	1.0E-08
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.2E-11	NA	NA
Aroclor-1260	8.5E-12	NA	NA
Arsenic	1.4E-12	3.0E-04	4.6E-09
Barium	1.4E-10	7.0E-02	1.9E-09
Beryllium	2.3E-15	5.0E-03	4.6E-13
Boron	8.8E-10	9.0E-02	9.7E-09
Cadmium	1.8E-11	1.0E-03	1.8E-08
Carbazole	NA	NA	NA
Chromium	7.9E-11	5.0E-03	1.6E-08
Cobalt	8.0E-11	6.0E-02	1.3E-09
Copper	1.3E-10	NA	NA
Cyanide	1.8E-17	2.0E-02	9.0E-16
Endrin	1.1E-14	3.0E-04	3.7E-11
Lead	2.3E-11	NA	NA
Manganese	1.2E-09	1.4E-01	8.3E-09
Mercury	5.6E-13	3.0E-04	1.9E-09
Molybdenum	3.5E-11	5.0E-03	7.1E-09
Nickel	7.8E-11	2.0E-02	3.9E-09
Selenium	1.1E-11	5.0E-03	2.2E-09
Silver	5.7E-10	5.0E-03	1.1E-07
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	3.8E-12	8.0E-05	4.7E-08
Thorium	NA	NA	NA
Uranium	1.5E-09	3.0E-03	5.0E-07
Vanadium	1.8E-12	7.0E-03	2.6E-10
Zinc	3.7E-09	3.0E-01	1.2E-08
	HQ Summation =		7.6E-07

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.2E-13	3.4E-01	1.4E-13
Antimony	4.1E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.2E-11	7.7E+00	9.6E-11
Aroclor-1260	8.5E-12	7.7E+00	6.5E-11
Arsenic	1.4E-12	1.8E+00	2.5E-12
Barium	1.4E-10	NA	NA
Beryllium	2.3E-15	4.3E+00	9.9E-15
Boron	8.8E-10	NA	NA
Cadmium	1.8E-11	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	7.9E-11	NA	NA
Cobalt	8.0E-11	NA	NA
Copper	1.3E-10	NA	NA
Cyanide	1.8E-17	NA	NA
Endrin	1.1E-14	NA	NA
Lead	2.3E-11	NA	NA
Manganese	1.2E-09	NA	NA
Mercury	5.6E-13	NA	NA
Molybdenum	3.5E-11	NA	NA
Nickel	7.8E-11	NA	NA
Selenium	1.1E-11	NA	NA
Silver	5.7E-10	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	3.8E-12	NA	NA
Thorium	NA	NA	NA
Uranium	1.5E-09	NA	NA
Vanadium	1.8E-12	NA	NA
Zinc	3.7E-09	NA	NA
	ILCR Summation =		1.6E-10

Table I.IV-117
Summary of Intake and Risk Quantitation (Radionuclides)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Ingestion of Milk Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.3 l/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	70 Year
Cp	Concentration of radionuclides in animal products	

Cs-137	3.55E-06	pCi/l	Ru-106	7.81E-32	pCi/l
Np-237	2.41E-05	pCi/l	Sr-90	1.78E-27	pCi/l
Pa-231	1.0E-07	pCi/l	Tc-99	1.04E-18	pCi/l
Pb-210	NA	pCi/l	Th-228	1.78E-09	pCi/l
Pu-238	3.2E-11	pCi/l	Th-230	1.35E-08	pCi/l
Pu-239	7.9E-12	pCi/l	Th-232	4.90E-09	pCi/l
Pu-240	2.9E-11	pCi/l	U-234	9.43E-01	pCi/l
Ra-226	1.4E-07	pCi/l	U-235	2.51E-02	pCi/l
Ra-228	2.5E-07	pCi/l	U-236	1.03E-02	pCi/l
Rn-222	NA	pCi/l	U-238	5.65E-01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	2.6E-02	2.8E-11	7.3E-13
Np-237	1.8E-01	2.2E-10	3.9E-11
Pa-231	7.6E-04	9.2E-11	7.0E-14
Pb-210	NA	6.6E-10	NA
Pu-238	2.3E-07	2.2E-10	5.1E-17
Pu-239	5.8E-08	2.3E-10	1.3E-17
Pu-240	2.1E-07	2.3E-10	4.9E-17
Ra-226	1.0E-03	1.2E-10	1.2E-13
Ra-228	1.8E-03	1.0E-10	1.8E-13
Rn-222	NA	1.7E-12	NA
Ru-106	5.7E-28	9.5E-12	5.5E-39
Sr-90	1.3E-23	3.6E-11	4.7E-34
Tc-99	7.7E-15	1.3E-12	1.0E-26
Th-228	1.3E-05	5.5E-11	7.2E-16
Th-230	9.9E-05	1.3E-11	1.3E-15
Th-232	3.6E-05	1.2E-11	4.3E-16
U-234	6.9E+03	1.6E-11	1.1E-07
U-235	1.8E+02	1.6E-11	2.9E-09
U-236	7.6E+01	1.5E-11	1.1E-09
U-238	4.2E+03	2.8E-11	1.2E-07
		ILCR Summation =	2.3E-07

Table I.IV-118
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
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
2-Methylnaphthalene	5.3E-10	mg/kg
4,4-DDE	1.4E-10	mg/kg
Antimony	7.4E-08	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	4.7E-09	mg/kg
Aroclor-1260	2.6E-09	mg/kg
Arsenic	7.3E-08	mg/kg
Barium	1.2E-06	mg/kg
Beryllium	8.1E-09	mg/kg
Boron	1.6E-06	mg/kg
Cadmium	5.2E-08	mg/kg
Carbazole	1.0E-09	mg/kg
Chromium	1.7E-07	mg/kg
Cobalt	1.3E-07	mg/kg
Copper	2.8E-07	mg/kg

Compound	Concentration	Units
Cyanide	3.1E-09	mg/kg
Endrin	2.0E-11	mg/kg
Lead	2.9E-07	mg/kg
Manganese	1.0E-05	mg/kg
Mercury	3.8E-09	mg/kg
Molybdenum	8.1E-08	mg/kg
Nickel	2.4E-07	mg/kg
Selenium	8.9E-09	mg/kg
Silver	8.8E-08	mg/kg
Tetrachlordibenzo-p-dioxin	2.8E-15	mg/kg
Thallium	6.0E-09	mg/kg
Thorium	3.1E-07	mg/kg
Uranium	7.9E-06	mg/kg
Vanadium	2.9E-07	mg/kg
Zinc	9.8E-07	mg/kg

References

Table I.IV-118 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Adult Future Land Use Without Federal Ownership
Via Ingestion of Vegetables and Fruits

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	1.2E-13	NA	NA
Antimony	6.2E-11	4.0E-04	1.6E-07
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	3.9E-12	NA	NA
Aroclor-1260	2.2E-12	NA	NA
Arsenic	6.1E-11	3.0E-04	2.0E-07
Barium	9.9E-10	7.0E-02	1.4E-08
Beryllium	6.8E-12	5.0E-03	1.4E-09
Boron	1.4E-09	9.0E-02	1.5E-08
Cadmium	4.4E-11	1.0E-03	4.4E-08
Carbazole	8.3E-13	NA	NA
Chromium	1.4E-10	5.0E-03	2.8E-08
Cobalt	1.1E-10	6.0E-02	1.8E-09
Copper	2.3E-10	NA	NA
Cyanide	2.6E-12	2.0E-02	1.3E-10
Endrin	1.7E-14	3.0E-04	5.6E-11
Lead	2.4E-10	NA	NA
Manganese	8.7E-09	1.4E-01	6.2E-08
Mercury	3.2E-12	3.0E-04	1.1E-08
Molybdenum	6.7E-11	5.0E-03	1.3E-08
Nickel	2.0E-10	2.0E-02	1.0E-08
Selenium	7.4E-12	5.0E-03	1.5E-09
Silver	7.4E-11	5.0E-03	1.5E-08
Tetrachlordibenzo-p-dioxin	2.3E-18	NA	NA
Thallium	5.0E-12	8.0E-05	6.2E-08
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	3.0E-03	2.2E-06
Vanadium	2.4E-10	7.0E-03	3.4E-08
Zinc	8.2E-10	3.0E-01	2.7E-09
	HQ Summation =		2.9E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	4.4E-13	NA	NA
4,4-DDE	1.2E-13	3.4E-01	4.0E-14
Antimony	6.2E-11	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	3.9E-12	7.7E+00	3.0E-11
Aroclor-1260	2.2E-12	7.7E+00	1.7E-11
Arsenic	6.1E-11	1.8E+00	1.1E-10
Barium	9.9E-10	NA	NA
Beryllium	6.8E-12	4.3E+00	2.9E-11
Boron	1.4E-09	NA	NA
Cadmium	4.4E-11	NA	NA
Carbazole	8.3E-13	2.0E-02	1.7E-14
Chromium	1.4E-10	NA	NA
Cobalt	1.1E-10	NA	NA
Copper	2.3E-10	NA	NA
Cyanide	2.6E-12	NA	NA
Endrin	1.7E-14	NA	NA
Lead	2.4E-10	NA	NA
Manganese	8.7E-09	NA	NA
Mercury	3.2E-12	NA	NA
Molybdenum	6.7E-11	NA	NA
Nickel	2.0E-10	NA	NA
Selenium	7.4E-12	NA	NA
Silver	7.4E-11	NA	NA
Tetrachlordibenzo-p-dioxin	2.3E-18	1.5E+05	3.5E-13
Thallium	5.0E-12	NA	NA
Thorium	2.6E-10	NA	NA
Uranium	6.6E-09	NA	NA
Vanadium	2.4E-10	NA	NA
Zinc	8.2E-10	NA	NA
	ILCR Summation =		1.9E-10

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Table I.IV–119
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Adult Future Land Use Without Federal Ownership
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	

Cs-137	6.51E-06	pCi/kg	Ru-106	4.38E-17	pCi/kg
Np-237	2.65E-06	pCi/kg	Sr-90	4.09E-16	pCi/kg
Pa-231	2.7E-06	pCi/kg	Tc-99	2.25E-07	pCi/kg
Pb-210	1.1E-05	pCi/kg	Th-228	4.75E-06	pCi/kg
Pu-238	4.1E-06	pCi/kg	Th-230	3.51E-05	pCi/kg
Pu-239	1.0E-06	pCi/kg	Th-232	1.28E-05	pCi/kg
Pu-240	3.8E-06	pCi/kg	U-234	1.28E+02	pCi/kg
Ra-226	4.2E-06	pCi/kg	U-235	3.41E+00	pCi/kg
Ra-228	7.3E-06	pCi/kg	U-236	1.40E+00	pCi/kg
Rn-222	3.6E-01	pCi/kg	U-238	7.68E+01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	9.7E-03	2.8E-11	2.7E-13
Np-237	4.0E-03	2.2E-10	8.7E-13
Pa-231	4.0E-03	9.2E-11	3.7E-13
Pb-210	1.7E-02	6.6E-10	1.1E-11
Pu-238	6.1E-03	2.2E-10	1.3E-12
Pu-239	1.5E-03	2.3E-10	3.5E-13
Pu-240	5.6E-03	2.3E-10	1.3E-12
Ra-226	6.2E-03	1.2E-10	7.5E-13
Ra-228	1.1E-02	1.0E-10	1.1E-12
Rn-222	5.4E+02	1.7E-12	9.2E-10
Ru-106	6.6E-14	9.5E-12	6.2E-25
Sr-90	6.1E-13	3.6E-11	2.2E-23
Tc-99	3.4E-04	1.3E-12	4.4E-16
Th-228	7.1E-03	5.5E-11	3.9E-13
Th-230	5.2E-02	1.3E-11	6.8E-13
Th-232	1.9E-02	1.2E-11	2.3E-13
U-234	1.9E+05	1.6E-11	3.1E-06
U-235	5.1E+03	1.6E-11	8.1E-08
U-236	2.1E+03	1.5E-11	3.1E-08
U-238	1.1E+05	2.8E-11	3.2E-06
		ILCR Summation =	6.4E-06

Table I.IV-120
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Intake 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 x 365)	2190 days
CS	Concentration of chemicals in soil	(see table below)

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	3.9E-09	mg/m^3
4,4-DDE	1.0E-09	mg/m^3
Antimony	5.5E-07	mg/m^3
Aroclor-1221	0.0E+00	mg/m^3
Aroclor-1248	0.0E+00	mg/m^3
Aroclor-1254	3.4E-08	mg/m^3
Aroclor-1260	1.9E-08	mg/m^3
Arsenic	5.3E-07	mg/m^3
Barium	8.7E-06	mg/m^3
Beryllium	6.0E-08	mg/m^3
Boron	1.1E-05	mg/m^3
Cadmium	3.7E-07	mg/m^3
Carbazole	7.3E-09	mg/m^3
Chromium	1.2E-06	mg/m^3
Cobalt	9.3E-07	mg/m^3
Copper	2.0E-06	mg/m^3

Compound	Concentration	Units
Cyanide	2.3E-08	mg/m^3
Endrin	1.5E-10	mg/m^3
Lead	2.1E-06	mg/m^3
Manganese	7.7E-05	mg/m^3
Mercury	2.8E-08	mg/m^3
Molybdenum	5.4E-07	mg/m^3
Nickel	1.8E-06	mg/m^3
Selenium	6.5E-08	mg/m^3
Silver	6.5E-07	mg/m^3
Tetrachlordibenzo-p-dioxin	2.1E-14	mg/m^3
Thallium	4.4E-08	mg/m^3
Thorium	2.3E-06	mg/m^3
Uranium	5.8E-05	mg/m^3
Vanadium	2.1E-06	mg/m^3
Zinc	6.3E-06	mg/m^3

References

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Table I.IV-120 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Inhalation of Particulates

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	3.0E-09	NA	NA
4,4-DDE	7.9E-10	NA	NA
Antimony	4.2E-07	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.6E-08	NA	NA
Aroclor-1260	1.5E-08	NA	NA
Arsenic	4.1E-07	NA	NA
Barium	6.7E-06	1.0E-04	6.7E-02
Beryllium	4.6E-08	NA	NA
Boron	8.5E-06	5.7E-03	1.5E-03
Cadmium	2.9E-07	NA	NA
Carbazole	5.6E-09	NA	NA
Chromium	9.4E-07	NA	NA
Cobalt	7.1E-07	3.0E-07	2.4E+00
Copper	1.6E-06	NA	NA
Cyanide	1.8E-08	NA	NA
Endrin	1.1E-10	NA	NA
Lead	1.6E-06	NA	NA
Manganese	5.9E-05	1.1E-04	5.3E-01
Mercury	2.1E-08	8.6E-05	2.5E-04
Molybdenum	4.1E-07	NA	NA
Nickel	1.4E-06	NA	NA
Selenium	5.0E-08	NA	NA
Silver	4.9E-07	NA	NA
Tetrachlordibenzo-p-dioxin	1.6E-14	NA	NA
Thallium	3.4E-08	NA	NA
Thorium	1.8E-06	NA	NA
Uranium	4.5E-05	NA	NA
Vanadium	1.6E-06	NA	NA
Zinc	4.8E-06	NA	NA
	Hazard Quotient Sum =		3.0E+00

Compound	ILCR Calculation CDI (mg/kg-day)	CSF (mg/kg-day)$^{-1}$	ILCR (unitless)
2-Methylnaphthalene	2.6E-10	NA	NA
4,4-DDE	6.8E-11	NA	NA
Antimony	3.6E-08	NA	NA
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	2.2E-09	NA	NA
Aroclor-1260	1.3E-09	NA	NA
Arsenic	3.5E-08	1.5E+01	5.3E-07
Barium	5.7E-07	NA	NA
Beryllium	3.9E-09	8.4E+00	3.3E-08
Boron	7.3E-07	NA	NA
Cadmium	2.5E-08	6.1E+00	1.5E-07
Carbazole	4.8E-10	NA	NA
Chromium	8.0E-08	4.1E+01	3.3E-06
Cobalt	6.1E-08	NA	NA
Copper	1.3E-07	NA	NA
Cyanide	1.5E-09	NA	NA
Endrin	9.7E-12	NA	NA
Lead	1.4E-07	NA	NA
Manganese	5.0E-06	NA	NA
Mercury	1.8E-09	NA	NA
Molybdenum	3.6E-08	NA	NA
Nickel	1.2E-07	8.4E-01	9.8E-08
Selenium	4.3E-09	NA	NA
Silver	4.2E-08	NA	NA
Tetrachlordibenzo-p-dioxin	1.4E-15	1.5E+05	2.0E-10
Thallium	2.9E-09	NA	NA
Thorium	1.5E-07	NA	NA
Uranium	3.8E-06	NA	NA
Vanadium	1.4E-07	NA	NA
Zinc	4.1E-07	NA	NA
	ILCR Summation =		4.1E-06

Table I.IV-121
Summary of Intake and Risk Quantitation (Radionuclides)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Inhalation of Gases and Particulates

Intake 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)

Cs-137	4.8E-05	pCi/m^3	Ru-106	8.3E-06	pCi/m^3
Np-237	2.0E-05	pCi/m^3	Sr-90	8.0E-05	pCi/m^3
Pa-231	2.0E-05	pCi/m^3	Tc-99	3.9E-04	pCi/m^3
Pb-210	8.3E-05	pCi/m^3	Th-228	3.6E-05	pCi/m^3
Pu-238	3.0E-05	pCi/m^3	Th-230	2.6E-04	pCi/m^3
Pu-239	7.6E-06	pCi/m^3	Th-232	9.4E-05	pCi/m^3
Pu-240	2.8E-05	pCi/m^3	U-234	2.4E-03	pCi/m^3
Ra-226	3.1E-05	pCi/m^3	U-235	9.8E-05	pCi/m^3
Ra-228	5.5E-05	pCi/m^3	U-236	5.8E-04	pCi/m^3
Rn-222	2.7E+00	pCi/m^3	U-238	1.2E-03	pCi/m^3

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	1.2E+00	1.9E-11	2.3E-11
Np-237	4.9E-01	2.9E-08	1.4E-08
Pa-231	5.0E-01	3.6E-08	1.8E-08
Pb-210	2.1E+00	4.0E-09	8.3E-09
Pu-238	7.6E-01	3.9E-08	3.0E-08
Pu-239	1.9E-01	3.8E-08	7.3E-09
Pu-240	7.0E-01	3.8E-08	2.6E-08
Ra-226	7.9E-01	3.0E-09	2.4E-09
Ra-228	1.4E+00	6.9E-10	9.5E-10
Rn-222	6.7E+04	7.7E-12	5.2E-07
Ru-106	2.1E-01	4.4E-10	9.2E-11
Sr-90	2.0E+00	6.2E-11	1.2E-10
Tc-99	9.8E+00	8.3E-12	8.1E-11
Th-228	9.0E-01	7.8E-08	7.0E-08
Th-230	6.5E+00	2.9E-08	1.9E-07
Th-232	2.4E+00	2.8E-08	6.6E-08
U-234	6.0E+01	2.6E-08	1.6E-06
U-235	2.5E+00	2.5E-08	6.1E-08
U-236	1.5E+01	2.5E-08	3.6E-07
U-238	3.0E+01	5.2E-11	1.6E-09
		ILCR Summation =	2.9E-06

Table I.IV-122
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Drinking Water Ingestion

Intake 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 x 365)	2190 days
CS	Concentration of chemicals in groundwater	

Chemical Concentrations

Compound	Concentration	Units	Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/l	Cyanide	NA	mg/l
4,4-DDE	NA	mg/l	Endrin	NA	mg/l
Antimony	6.90E-08	mg/l	Lead	NA	mg/l
Aroclor-1221	1.03E-27	mg/l	Manganese	NA	mg/l
Aroclor-1248	NA	mg/l	Mercury	NA	mg/l
Aroclor-1254	NA	mg/l	Molybdenum	NA	mg/l
Aroclor-1260	NA	mg/l	Nickel	NA	mg/l
Arsenic	NA	mg/l	Selenium	NA	mg/l
Barium	NA	mg/l	Silver	NA	mg/l
Beryllium	NA	mg/l	Tetrachlordibenzo-p-dioxin	NA	mg/l
Boron	NA	mg/l	Thallium	NA	mg/l
Cadmium	1.71E-24	mg/l	Thorium	NA	mg/l
Carbazole	NA	mg/l	Uranium	NA	mg/l
Chromium	NA	mg/l	Vanadium	NA	mg/l
Cobalt	NA	mg/l	Zinc	NA	mg/l
Copper	NA	mg/l			

References

Table I.IV-122
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Drinking Water Ingestion

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	NA	NA
Antimony	4.4E-09	4.0E-04	1.1E-05
Aroclor-1221	6.6E-29	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	NA	NA	NA
Aroclor-1260	NA	NA	NA
Arsenic	NA	3.0E-04	0.0E+00
Barium	NA	7.0E-02	0.0E+00
Beryllium	NA	5.0E-03	0.0E+00
Boron	NA	9.0E-02	0.0E+00
Cadmium	1.1E-25	1.0E-03	1.1E-22
Carbazole	NA	NA	NA
Chromium	NA	5.0E-03	0.0E+00
Cobalt	NA	6.0E-02	0.0E+00
Copper	NA	NA	NA
Cyanide	NA	2.0E-02	0.0E+00
Endrin	NA	3.0E-04	0.0E+00
Lead	NA	NA	NA
Manganese	NA	1.4E-01	0.0E+00
Mercury	NA	3.0E-04	0.0E+00
Molybdenum	NA	5.0E-03	0.0E+00
Nickel	NA	2.0E-02	0.0E+00
Selenium	NA	5.0E-03	0.0E+00
Silver	NA	5.0E-03	0.0E+00
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	NA	8.0E-05	0.0E+00
Thorium	NA	NA	NA
Uranium	NA	3.0E-03	0.0E+00
Vanadium	NA	7.0E-03	0.0E+00
Zinc	NA	3.0E-01	0.0E+00
	HQ Summation =		1.1E-05

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	NA	3.4E-01	NA
Antimony	3.8E-10	NA	0.0E+00
Aroclor-1221	5.6E-30	7.7E+00	4.3E-29
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	NA	7.7E+00	NA
Aroclor-1260	NA	7.7E+00	NA
Arsenic	NA	1.8E+00	NA
Barium	NA	NA	NA
Beryllium	NA	4.3E+00	NA
Boron	NA	NA	NA
Cadmium	9.4E-27	NA	0.0E+00
Carbazole	NA	2.0E-02	NA
Chromium	NA	NA	NA
Cobalt	NA	NA	NA
Copper	NA	NA	NA
Cyanide	NA	NA	NA
Endrin	NA	NA	NA
Lead	NA	NA	NA
Manganese	NA	NA	NA
Mercury	NA	NA	NA
Molybdenum	NA	NA	NA
Nickel	NA	NA	NA
Selenium	NA	NA	NA
Silver	NA	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	NA	NA	NA
Thorium	NA	NA	NA
Uranium	NA	NA	NA
Vanadium	NA	NA	NA
Zinc	NA	NA	NA
	ILCR Summation =		4.3E-29

Table I.IV-123
Summary of Intake and Risk Quantitation (Radionuclides)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Drinking Water

Intake 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	

Cs-137	NA	pCi/l	Ru-106	NA	pCi/l
Np-237	8.0E-02	pCi/l	Sr-90	NA	pCi/l
Pa-231	NA	pCi/l	Tc-99	1.2E+03	pCi/l
Pb-210	NA	pCi/l	Th-228	NA	pCi/l
Pu-238	NA	pCi/l	Th-230	NA	pCi/l
Pu-239	NA	pCi/l	Th-232	NA	pCi/l
Pu-240	NA	pCi/l	U-234	2.6E+01	pCi/l
Ra-226	NA	pCi/l	U-235	7.0E-01	pCi/l
Ra-228	NA	pCi/l	U-236	2.9E-01	pCi/l
Rn-222	NA	pCi/l	U-238	1.6E+01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	NA	2.8E-11	NA
Np-237	1.7E+02	2.2E-10	3.7E-08
Pa-231	NA	9.2E-11	NA
Pb-210	NA	6.6E-10	NA
Pu-238	NA	2.2E-10	NA
Pu-239	NA	2.3E-10	NA
Pu-240	NA	2.3E-10	NA
Ra-226	NA	1.2E-10	NA
Ra-228	NA	1.0E-10	NA
Rn-222	NA	1.7E-12	NA
Ru-106	NA	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	2.6E+06	1.3E-12	3.3E-06
Th-228	NA	5.5E-11	NA
Th-230	NA	1.3E-11	NA
Th-232	NA	1.2E-11	NA
U-234	5.5E+04	1.6E-11	8.8E-07
U-235	1.5E+03	1.6E-11	2.3E-08
U-236	6.0E+02	1.5E-11	9.0E-09
U-238	3.3E+04	2.8E-11	9.2E-07
		ILCR Summation =	5.2E-06

Table I.IV-124
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
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	0.029	kg/day
FI	Fraction ingested from contaminated source	1	(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 x 365)	2190	days
CS	Concentration of chemicals in meat		

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	0.0E+00	mg/kg
4,4-DDE	5.3E-10	mg/kg
Antimony	9.2E-09	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	9.6E-09	mg/kg
Aroclor-1260	6.5E-09	mg/kg
Arsenic	1.1E-08	mg/kg
Barium	1.4E-08	mg/kg
Beryllium	6.2E-10	mg/kg
Boron	1.1E-07	mg/kg
Cadmium	2.4E-09	mg/kg
Carbazole	0.0E+00	mg/kg
Chromium	7.0E-08	mg/kg
Cobalt	1.9E-07	mg/kg
Copper	2.2E-07	mg/kg

Compound	Concentration	Units
Cyanide	1.4E-14	mg/kg
Endrin	1.8E-11	mg/kg
Lead	6.7E-09	mg/kg
Manganese	3.2E-07	mg/kg
Mercury	7.6E-08	mg/kg
Molybdenum	3.4E-08	mg/kg
Nickel	1.1E-07	mg/kg
Selenium	1.0E-08	mg/kg
Silver	2.1E-08	mg/kg
Tetrachlordibenzo-p-dioxin	0.0E+00	mg/kg
Thallium	1.8E-08	mg/kg
Thorium	0.0E+00	mg/kg
Uranium	1.2E-07	mg/kg
Vanadium	5.5E-08	mg/kg
Zinc	9.0E-06	mg/kg

References

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Table I.IV-124 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	9.8E-13	NA	NA
Antimony	1.7E-11	4.0E-04	4.3E-08
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.8E-11	NA	NA
Aroclor-1260	1.2E-11	NA	NA
Arsenic	2.1E-11	3.0E-04	7.0E-08
Barium	2.6E-11	7.0E-02	3.7E-10
Beryllium	1.2E-12	5.0E-03	2.3E-10
Boron	2.1E-10	9.0E-02	2.3E-09
Cadmium	4.5E-12	1.0E-03	4.5E-09
Carbazole	NA	NA	NA
Chromium	1.3E-10	5.0E-03	2.6E-08
Cobalt	3.6E-10	6.0E-02	6.0E-09
Copper	4.0E-10	NA	NA
Cyanide	2.5E-17	2.0E-02	1.3E-15
Endrin	3.4E-14	3.0E-04	1.1E-10
Lead	1.2E-11	NA	NA
Manganese	6.0E-10	1.4E-01	4.3E-09
Mercury	1.4E-10	3.0E-04	4.7E-07
Molybdenum	6.4E-11	5.0E-03	1.3E-08
Nickel	2.1E-10	2.0E-02	1.0E-08
Selenium	1.9E-11	5.0E-03	3.8E-09
Silver	3.8E-11	5.0E-03	7.7E-09
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	3.4E-11	8.0E-05	4.3E-07
Thorium	NA	NA	NA
Uranium	2.3E-10	3.0E-03	7.5E-08
Vanadium	1.0E-10	7.0E-03	1.5E-08
Zinc	1.7E-08	3.0E-01	5.6E-08
	HQ Summation =		1.2E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	8.4E-14	3.4E-01	2.9E-14
Antimony	1.5E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.5E-12	7.7E+00	1.2E-11
Aroclor-1260	1.0E-12	7.7E+00	8.0E-12
Arsenic	1.8E-12	1.8E+00	3.2E-12
Barium	2.2E-12	NA	NA
Beryllium	9.9E-14	4.3E+00	4.3E-13
Boron	1.8E-11	NA	NA
Cadmium	3.9E-13	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	1.1E-11	NA	NA
Cobalt	3.1E-11	NA	NA
Copper	3.4E-11	NA	NA
Cyanide	2.2E-18	NA	NA
Endrin	2.9E-15	NA	NA
Lead	1.1E-12	NA	NA
Manganese	5.2E-11	NA	NA
Mercury	1.2E-11	NA	NA
Molybdenum	5.5E-12	NA	NA
Nickel	1.8E-11	NA	NA
Selenium	1.6E-12	NA	NA
Silver	3.3E-12	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	2.9E-12	NA	NA
Thorium	NA	NA	NA
Uranium	1.9E-11	NA	NA
Vanadium	8.8E-12	NA	NA
Zinc	1.4E-09	NA	NA
	ILCR Summation =		2.3E-11

Table I.IV–125
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Meat Products

Intake Equation = Cf X EF X EDn X FI X IR

IR	Ingestion rate of meat	0.029 kg/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cf	Concentration of radionuclides in meat	

Cs-137	1.01E-05	pCi/kg	Ru-106	0.00E+00	pCi/kg
Np-237	2.21E-04	pCi/kg	Sr-90	NA	pCi/kg
Pa-231	1.7E-05	pCi/kg	Tc-99	NA	pCi/kg
Pb-210	0.0E+00	pCi/kg	Th-228	1.39E-09	pCi/kg
Pu-238	1.6E-10	pCi/kg	Th-230	1.62E-08	pCi/kg
Pu-239	4.0E-11	pCi/kg	Th-232	5.88E-09	pCi/kg
Pu-240	1.4E-10	pCi/kg	U-234	2.62E-01	pCi/kg
Ra-226	5.1E-08	pCi/kg	U-235	6.96E-03	pCi/kg
Ra-228	8.9E-08	pCi/kg	U-236	2.87E-03	pCi/kg
Rn-222	0.0E+00	pCi/kg	U-238	1.57E-01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	6.2E-04	2.8E-11	1.7E-14
Np-237	1.3E-02	2.2E-10	3.0E-12
Pa-231	1.0E-03	9.2E-11	9.3E-14
Pb-210	0.0E+00	6.6E-10	NA
Pu-238	9.6E-09	2.2E-10	2.1E-18
Pu-239	2.4E-09	2.3E-10	5.6E-19
Pu-240	8.8E-09	2.3E-10	2.0E-18
Ra-226	3.1E-06	1.2E-10	3.7E-16
Ra-228	5.4E-06	1.0E-10	5.4E-16
Rn-222	0.0E+00	1.7E-12	NA
Ru-106	0.0E+00	9.5E-12	NA
Sr-90	NA	3.6E-11	NA
Tc-99	NA	1.3E-12	NA
Th-228	8.5E-08	5.5E-11	4.7E-18
Th-230	9.8E-07	1.3E-11	1.3E-17
Th-232	3.6E-07	1.2E-11	4.3E-18
U-234	1.6E+01	1.6E-11	2.6E-10
U-235	4.2E-01	1.6E-11	6.8E-12
U-236	1.7E-01	1.5E-11	2.6E-12
U-238	9.6E+00	2.8E-11	2.7E-10
		ILCR Summation =	5.4E-10

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Table I.IV-126
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
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	0.68 l/day
FI	Fraction ingested from contaminated source	1 (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 x 365)	2190 days
CS	Concentration of chemicals in animal products	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	NA	mg/l
4,4-DDE	1.0E-10	mg/l
Antimony	9.9E-10	mg/l
Aroclor-1221	NA	mg/l
Aroclor-1248	NA	mg/l
Aroclor-1254	3.0E-09	mg/l
Aroclor-1260	2.1E-09	mg/l
Arsenic	3.4E-10	mg/l
Barium	3.3E-08	mg/l
Beryllium	5.6E-13	mg/l
Boron	2.1E-07	mg/l
Cadmium	4.4E-09	mg/l
Carbazole	NA	mg/l
Chromium	1.9E-08	mg/l
Cobalt	1.9E-08	mg/l
Copper	3.3E-08	mg/l

Compound	Concentration	Units
Cyanide	4.4E-15	mg/l
Endrin	2.7E-12	mg/l
Lead	5.5E-09	mg/l
Manganese	2.8E-07	mg/l
Mercury	1.4E-10	mg/l
Molybdenum	8.6E-09	mg/l
Nickel	1.9E-08	mg/l
Selenium	2.7E-09	mg/l
Silver	1.4E-07	mg/l
Tetrachlordibenzo-p-dioxin	NA	mg/l
Thallium	9.2E-10	mg/l
Thorium	NA	mg/l
Uranium	3.7E-07	mg/l
Vanadium	4.4E-10	mg/l
Zinc	9.0E-07	mg/l

References

Table I.IV-126 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Dairy Products

Compound	HQ Calculation CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	4.5E-12	NA	NA
Antimony	4.3E-11	4.0E-04	1.1E-07
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.3E-10	NA	NA
Aroclor-1260	8.9E-11	NA	NA
Arsenic	1.5E-11	3.0E-04	4.9E-08
Barium	1.4E-09	7.0E-02	2.0E-08
Beryllium	2.4E-14	5.0E-03	4.9E-12
Boron	9.3E-09	9.0E-02	1.0E-07
Cadmium	1.9E-10	1.0E-03	1.9E-07
Carbazole	NA	NA	NA
Chromium	8.3E-10	5.0E-03	1.7E-07
Cobalt	8.5E-10	6.0E-02	1.4E-08
Copper	1.4E-09	NA	NA
Cyanide	1.9E-16	2.0E-02	9.5E-15
Endrin	1.2E-13	3.0E-04	3.9E-10
Lead	2.4E-10	NA	NA
Manganese	1.2E-08	1.4E-01	8.8E-08
Mercury	5.9E-12	3.0E-04	2.0E-08
Molybdenum	3.7E-10	5.0E-03	7.5E-08
Nickel	8.2E-10	2.0E-02	4.1E-08
Selenium	1.2E-10	5.0E-03	2.4E-08
Silver	6.0E-09	5.0E-03	1.2E-06
Tetrachlordibenzo-p-dioxin	NA	NA	NA
Thallium	4.0E-11	8.0E-05	5.0E-07
Thorium	NA	NA	NA
Uranium	1.6E-08	3.0E-03	5.3E-06
Vanadium	1.9E-11	7.0E-03	2.7E-09
Zinc	3.9E-08	3.0E-01	1.3E-07
	HQ Summation =		8.0E-06

Compound	ILCR Calculation CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	NA	NA	NA
4,4-DDE	3.8E-13	3.4E-01	1.3E-13
Antimony	3.7E-12	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.1E-11	7.7E+00	8.7E-11
Aroclor-1260	7.7E-12	7.7E+00	5.9E-11
Arsenic	1.3E-12	1.8E+00	2.3E-12
Barium	1.2E-10	NA	NA
Beryllium	2.1E-15	4.3E+00	9.0E-15
Boron	7.9E-10	NA	NA
Cadmium	1.7E-11	NA	NA
Carbazole	NA	2.0E-02	NA
Chromium	7.1E-11	NA	NA
Cobalt	7.3E-11	NA	NA
Copper	1.2E-10	NA	NA
Cyanide	1.6E-17	NA	NA
Endrin	1.0E-14	NA	NA
Lead	2.1E-11	NA	NA
Manganese	1.1E-09	NA	NA
Mercury	5.1E-13	NA	NA
Molybdenum	3.2E-11	NA	NA
Nickel	7.0E-11	NA	NA
Selenium	1.0E-11	NA	NA
Silver	5.1E-10	NA	NA
Tetrachlordibenzo-p-dioxin	NA	1.5E+05	NA
Thallium	3.4E-12	NA	NA
Thorium	NA	NA	NA
Uranium	1.4E-09	NA	NA
Vanadium	1.6E-12	NA	NA
Zinc	3.4E-09	NA	NA
	ILCR Summation =		1.5E-10

Table I.IV–127
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Dairy Products

Intake Equation = Cp X EF X EDn X FI X IR

IR	Ingestion rate of dairy products	0.68 l/day
FI	Fraction ingested from contaminated source	1 (Unitless)
EF	Exposure frequency	350 days/year
EDn	Exposure duration	6 Year
Cp	Concentration of radionuclides in animal products	

Cs-137	3.55E-06	pCi/l	Ru-106	7.81E-32	pCi/l
Np-237	2.41E-05	pCi/l	Sr-90	1.78E-27	pCi/l
Pa-231	1.0E-07	pCi/l	Tc-99	1.04E-18	pCi/l
Pb-210	NA	pCi/l	Th-228	1.78E-09	pCi/l
Pu-238	3.2E-11	pCi/l	Th-230	1.35E-08	pCi/l
Pu-239	7.9E-12	pCi/l	Th-232	4.90E-09	pCi/l
Pu-240	2.9E-11	pCi/l	U-234	9.43E-01	pCi/l
Ra-226	1.4E-07	pCi/l	U-235	2.51E-02	pCi/l
Ra-228	2.5E-07	pCi/l	U-236	1.03E-02	pCi/l
Rn-222	NA	pCi/l	U-238	5.65E-01	pCi/l

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	5.1E-03	2.8E-11	1.4E-13
Np-237	3.4E-02	2.2E-10	7.6E-12
Pa-231	1.5E-04	9.2E-11	1.4E-14
Pb-210	NA	6.6E-10	NA
Pu-238	4.5E-08	2.2E-10	9.9E-18
Pu-239	1.1E-08	2.3E-10	2.6E-18
Pu-240	4.1E-08	2.3E-10	9.5E-18
Ra-226	2.0E-04	1.2E-10	2.4E-14
Ra-228	3.5E-04	1.0E-10	3.5E-14
Rn-222	NA	1.7E-12	NA
Ru-106	1.1E-28	9.5E-12	1.1E-39
Sr-90	2.5E-24	3.6E-11	9.1E-35
Tc-99	1.5E-15	1.3E-12	1.9E-27
Th-228	2.5E-06	5.5E-11	1.4E-16
Th-230	1.9E-05	1.3E-11	2.5E-16
Th-232	7.0E-06	1.2E-11	8.4E-17
U-234	1.3E+03	1.6E-11	2.2E-08
U-235	3.6E+01	1.6E-11	5.7E-10
U-236	1.5E+01	1.5E-11	2.2E-10
U-238	8.1E+02	2.8E-11	2.3E-08
		ILCR Summation =	4.5E-08

Table I.IV-128 (continued)
Summary of Risk Characterization (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Vegetables and Fruits

Compound	HQ Calculation		
	CDI (mg/kg-day)	RfD (mg/kg-day)	HQ (unitless)
2-Methylnaphthalene	1.8E-12	NA	NA
4,4-DDE	4.8E-13	NA	NA
Antimony	2.5E-10	4.0E-04	6.3E-07
Aroclor-1221	NA	NA	NA
Aroclor-1248	NA	NA	NA
Aroclor-1254	1.6E-11	NA	NA
Aroclor-1260	8.9E-12	NA	NA
Arsenic	2.5E-10	3.0E-04	8.2E-07
Barium	4.0E-09	7.0E-02	5.7E-08
Beryllium	2.7E-11	5.0E-03	5.5E-09
Boron	5.5E-09	9.0E-02	6.1E-08
Cadmium	1.8E-10	1.0E-03	1.8E-07
Carbazole	3.4E-12	NA	NA
Chromium	5.6E-10	5.0E-03	1.1E-07
Cobalt	4.3E-10	6.0E-02	7.1E-09
Copper	9.4E-10	NA	NA
Cyanide	1.1E-11	2.0E-02	5.3E-10
Endrin	6.8E-14	3.0E-04	2.3E-10
Lead	9.7E-10	NA	NA
Manganese	3.5E-08	1.4E-01	2.5E-07
Mercury	1.3E-11	3.0E-04	4.3E-08
Molybdenum	2.7E-10	5.0E-03	5.5E-08
Nickel	8.3E-10	2.0E-02	4.1E-08
Selenium	3.0E-11	5.0E-03	6.0E-09
Silver	3.0E-10	5.0E-03	6.0E-08
Tetrachlordibenzo-p-dioxin	9.5E-18	NA	NA
Thallium	2.0E-11	8.0E-05	2.5E-07
Thorium	1.1E-09	NA	NA
Uranium	2.7E-08	3.0E-03	9.0E-06
Vanadium	9.7E-10	7.0E-03	1.4E-07
Zinc	3.3E-09	3.0E-01	1.1E-08
	HQ Summation =		1.2E-05

Compound	ILCR Calculation		
	CDI (mg/kg-day)	CSF $(mg/kg-day)^{-1}$	ILCR (unitless)
2-Methylnaphthalene	1.5E-13	NA	NA
4,4-DDE	4.1E-14	3.4E-01	1.4E-14
Antimony	2.2E-11	NA	NA
Aroclor-1221	NA	7.7E+00	NA
Aroclor-1248	NA	7.7E+00	NA
Aroclor-1254	1.4E-12	7.7E+00	1.0E-11
Aroclor-1260	7.6E-13	7.7E+00	5.9E-12
Arsenic	2.1E-11	1.8E+00	3.8E-11
Barium	3.4E-10	NA	NA
Beryllium	2.4E-12	4.3E+00	1.0E-11
Boron	4.7E-10	NA	NA
Cadmium	1.5E-11	NA	NA
Carbazole	2.9E-13	2.0E-02	5.8E-15
Chromium	4.8E-11	NA	NA
Cobalt	3.7E-11	NA	NA
Copper	8.1E-11	NA	NA
Cyanide	9.0E-13	NA	NA
Endrin	5.8E-15	NA	NA
Lead	8.3E-11	NA	NA
Manganese	3.0E-09	NA	NA
Mercury	1.1E-12	NA	NA
Molybdenum	2.3E-11	NA	NA
Nickel	7.1E-11	NA	NA
Selenium	2.6E-12	NA	NA
Silver	2.6E-11	NA	NA
Tetrachlordibenzo-p-dioxin	8.1E-19	1.5E+05	1.2E-13
Thallium	1.7E-12	NA	NA
Thorium	9.1E-11	NA	NA
Uranium	2.3E-09	NA	NA
Vanadium	8.3E-11	NA	NA
Zinc	2.8E-10	NA	NA
	ILCR Summation =		6.5E-11

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Table I.IV-128
Summary of Intake Quantitation (chemicals)
Off-Property RME Resident Farm Child Future Land Use Without Federal Ownership
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	0.106 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 x 365)	2190 days
CS	Concentration of chemicals in vegetables	

Chemical Concentrations

Compound	Concentration	Units
2-Methylnaphthalene	5.3E-10	mg/kg
4,4-DDE	1.4E-10	mg/kg
Antimony	7.4E-08	mg/kg
Aroclor-1221	0.0E+00	mg/kg
Aroclor-1248	0.0E+00	mg/kg
Aroclor-1254	4.7E-09	mg/kg
Aroclor-1260	2.6E-09	mg/kg
Arsenic	7.3E-08	mg/kg
Barium	1.2E-06	mg/kg
Beryllium	8.1E-09	mg/kg
Boron	1.6E-06	mg/kg
Cadmium	5.2E-08	mg/kg
Carbazole	1.0E-09	mg/kg
Chromium	1.7E-07	mg/kg
Cobalt	1.3E-07	mg/kg
Copper	2.8E-07	mg/kg

Compound	Concentration	Units
Cyanide	3.1E-09	mg/kg
Endrin	2.0E-11	mg/kg
Lead	2.9E-07	mg/kg
Manganese	1.0E-05	mg/kg
Mercury	3.8E-09	mg/kg
Molybdenum	8.1E-08	mg/kg
Nickel	2.4E-07	mg/kg
Selenium	8.9E-09	mg/kg
Silver	8.8E-08	mg/kg
Tetrachlordibenzo-p-dioxin	2.8E-15	mg/kg
Thallium	6.0E-09	mg/kg
Thorium	3.1E-07	mg/kg
Uranium	7.9E-06	mg/kg
Vanadium	2.9E-07	mg/kg
Zinc	9.8E-07	mg/kg

References

Table I.IV–129
Summary of Intake and Risk Quantitation (Radionuclides)
Off–Property RME Resident Farm Child Future Land Use Without Federal Ownership
Via Ingestion of Vegetables and Fruits

Intake Equation = Cv X EF X EDn X FI X IR

IR	Ingestion rate of fruits or vegetables	0.106 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	

Cs-137	6.51E-06	pCi/kg	Ru-106	4.38E-17	pCi/kg
Np-237	2.65E-06	pCi/kg	Sr-90	4.09E-16	pCi/kg
Pa-231	2.7E-06	pCi/kg	Tc-99	2.25E-07	pCi/kg
Pb-210	1.1E-05	pCi/kg	Th-228	4.75E-06	pCi/kg
Pu-238	4.1E-06	pCi/kg	Th-230	3.51E-05	pCi/kg
Pu-239	1.0E-06	pCi/kg	Th-232	1.28E-05	pCi/kg
Pu-240	3.8E-06	pCi/kg	U-234	1.28E+02	pCi/kg
Ra-226	4.2E-06	pCi/kg	U-235	3.41E+00	pCi/kg
Ra-228	7.3E-06	pCi/kg	U-236	1.40E+00	pCi/kg
Rn-222	3.6E-01	pCi/kg	U-238	7.68E+01	pCi/kg

Radionuclides	CDI (pCi)	CSF $(pCi)^{-1}$	ILCR (unitless)
Cs-137	7.3E-04	2.8E-11	2.0E-14
Np-237	3.0E-04	2.2E-10	6.5E-14
Pa-231	3.0E-04	9.2E-11	2.8E-14
Pb-210	1.2E-03	6.6E-10	8.2E-13
Pu-238	4.6E-04	2.2E-10	1.0E-13
Pu-239	1.1E-04	2.3E-10	2.6E-14
Pu-240	4.2E-04	2.3E-10	9.6E-14
Ra-226	4.6E-04	1.2E-10	5.6E-14
Ra-228	8.1E-04	1.0E-10	8.1E-14
Rn-222	4.0E+01	1.7E-12	6.8E-11
Ru-106	4.9E-15	9.5E-12	4.6E-26
Sr-90	4.6E-14	3.6E-11	1.6E-24
Tc-99	2.5E-05	1.3E-12	3.3E-17
Th-228	5.3E-04	5.5E-11	2.9E-14
Th-230	3.9E-03	1.3E-11	5.1E-14
Th-232	1.4E-03	1.2E-11	1.7E-14
U-234	1.4E+04	1.6E-11	2.3E-07
U-235	3.8E+02	1.6E-11	6.1E-09
U-236	1.6E+02	1.5E-11	2.3E-09
U-238	8.6E+03	2.8E-11	2.4E-07
		ILCR Summation =	4.8E-07

ATTACHMENT I.IV-2

TARGET ORGAN IMPACT CALCULATIONS

TABLE I.IV-3
HAZARD QUOTIENTS FOR THE OFF-PROPERTY RESIDENT FARM CHILD (RME), CURRENT LAND USE

Chemical	Target Organs: Oral	Target Organs: Inhalation	Media: Soil	Media: Air	Media: Water	Media: Food	Total
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY				4.87E-05	9.89E-07	4.97E-05
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S					9.39E-07	9.39E-07
Barium	CVS	F		6.67E-02		7.81E-08	6.67E-02
Beryllium	NO					5.73E-09	5.73E-09
Boron	T	R		1.49E-03		1.66E-07	1.49E-03
Cadmium	K				2.60E-29	3.74E-07	3.74E-07
Carbazole							
Chromium	NO					3.05E-07	3.05E-07
Cobalt	CVS	L		2.38E+00		2.73E-08	2.38E+00
Copper							
Cyanide	BDY					5.27E-10	5.27E-10
Endrin	CNS					7.27E-10	7.27E-10
Lead							
Manganese	CNS	CNS		5.35E-01		3.45E-07	5.35E-01
Mercury	K	CNS		2.47E-04		5.32E-07	2.48E-04
Molybdenum	U					1.42E-07	1.42E-07
Nickel	BDY					9.29E-08	9.29E-08
Selenium	BDY					3.36E-08	3.36E-08
Silver	S					1.26E-06	1.26E-06
Tetrachlordibenzo-p-dioxin							
Thallium	NO					1.18E-06	1.18E-06
Thorium							
Uranium	K					1.43E-05	1.43E-05
Vanadium						1.56E-07	1.56E-07
Zinc	B					1.98E-07	1.98E-07
Total Hazard Index			NC	2.98E+00	4.87E-05	2.12E-05	2.98E+00

Total - Liver	2.38E+00
Total - Fetus	6.67E-02
Total - CVS	1.05E-07
Total - Kidney	1.53E-05
Total - Respiratory	1.49E-03
Total - CNS	5.35E-01
Total - Blood	1.98E-07
Total - Whole Body	4.99E-05
Total - Skin	2.20E-06
Total - Testis	1.66E-07
Total - Urine	1.42E-07
Total - NO	1.49E-06

B - Blood, CNS - Central Nervous System, CVS - Cardiovascular System,
F - Fetus, K - Kidney, L - Liver, R - Respiratory System, S - Skin,
U - Urine, BDY - Whole Body, ND - No Data available, NO - None observed
T - Testis

Note:
NC - Not calculated, incomplete pathway

TABLE I.IV-2
HAZARD QUOTIENTS FOR THE OFF-PROPERTY RESIDENT FARM ADULT (RME), CURRENT LAND USE

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY				2.09E-05	2.34E-07	2.11E-05
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S					2.46E-07	2.46E-07
Barium	CVS	F		2.38E-02		1.63E-08	2.38E-02
Beryllium	NO					1.48E-09	1.48E-09
Boron	T	R		5.34E-04		2.61E-08	5.34E-04
Cadmium	K				1.12E-29	6.43E-08	6.43E-08
Carbazole							
Chromium	NO					5.79E-08	5.79E-08
Cobalt	CVS	L		8.50E-01		6.43E-09	8.50E-01
Copper							
Cyanide	BDY					1.30E-10	1.30E-10
Endrin	CNS					1.55E-10	1.55E-10
Lead							
Manganese	CNS	CNS		1.91E-01		7.31E-08	1.91E-01
Mercury	K	CNS		8.82E-05		2.73E-07	8.85E-05
Molybdenum	U					2.76E-08	2.76E-08
Nickel	BDY					1.99E-08	1.99E-08
Selenium	BDY					5.84E-09	5.84E-09
Silver	S					1.32E-07	1.32E-07
Tetrachlordibenzo-p-dioxin							
Thallium	NO					3.46E-07	3.46E-07
Thorium							
Uranium	K					2.75E-06	2.75E-06
Vanadium						4.26E-08	4.26E-08
Zinc	B					4.60E-08	4.60E-08
Total Hazard Index			NC	1.07E+00	2.09E-05	4.37E-06	1.07E+00

Total – Liver	8.50E-01
Total – Fetus	2.38E-02
Total – CVS	2.27E-08
Total – Kidney	3.09E-06
Total – Respiratory	5.34E-04
Total – CNS	1.91E-01
Total – Blood	4.60E-08
Total – Whole Body	2.12E-05
Total – Skin	3.78E-07
Total – Testis	2.61E-08
Total – Urine	2.76E-08
Total – NO	4.05E-07

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – No data available
T – Testis, NO – None observed

Note:
NC – Not calculated, incomplete pathway

TABLE I.IV-1
HAZARD QUOTIENTS FOR THE GROUNDSKEEPER (RME)
CURRENT LAND USE

Chemical	Target Organs: Oral	Target Organs: Inhalation	Media: Soil	Media: Air	Media: Water	Media: Food	Total
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY		6.33E-02				6.33E-02
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S		1.76E-02				1.76E-02
Barium	CVS	F	2.22E-03	1.70E-02			1.92E-02
Beryllium	NO		8.64E-03				8.64E-03
Boron	T	R	1.52E-02	3.81E-04			1.56E-02
Cadmium	K		4.26E-02				4.26E-02
Carbazole							
Chromium	NO		7.31E-03				7.31E-03
Cobalt	CVS	L	4.49E-04	6.07E-01			6.08E-01
Copper			5.17E-05				5.17E-05
Cyanide	BDY		1.22E-05				1.22E-05
Endrin	CNS						
Lead							
Manganese	CNS	CNS	1.38E-01	1.36E-01			2.74E-01
Mercury	K	CNS	1.41E-02	6.30E-05			1.41E-02
Molybdenum	U		3.19E-03				3.19E-03
Nickel	BDY		1.42E-03				1.42E-03
Selenium	BDY		2.12E-04				2.12E-04
Silver	S		1.18E-03				1.18E-03
Tetrachlordibenzo-p-dioxin							
Thallium	NO		1.21E-02				1.21E-02
Thorium							
Uranium	K						
Vanadium	ND		7.81E-03				7.81E-03
Zinc	B		6.90E-04				6.90E-04
Total Hazard Index			3.36E-01	7.61E-01	NC	NC	1.10E+00

Total – Liver	6.07E-01
Total – Fetus	1.70E-02
Total – CVS	2.67E-03
Total – Kidney	5.66E-02
Total – Respiratory	3.81E-04
Total – CNS	2.74E-01
Total – Blood	6.90E-04
Total – Whole Body	6.49E-02
Total – Skin	1.88E-02
Total – Testis	1.52E-02
Total – Urine	3.19E-03
Total – NO	2.80E-02

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – No data available
T – Testis

Note:
NC – Not calculated, incomplete pathway
NO – None observed

TABLE I.IV-4
HAZARD QUOTIENTS FOR THE OFF-PROPERTY RESIDENT FARM ADULT (RME), FUTURE LAND USE WITH FEDERAL OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY				4.73E-06	1.89E-07	4.92E-06
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S					2.46E-07	2.46E-07
Barium	CVS	F		2.38E-02		1.63E-08	2.38E-02
Beryllium	NO					1.48E-09	1.48E-09
Boron	T	R		5.34E-04		2.61E-08	5.34E-04
Cadmium	K				4.68E-23	6.43E-08	6.43E-08
Carbazole							
Chromium	NO					5.79E-08	5.79E-08
Cobalt	CVS	L		8.50E-01		6.43E-09	8.50E-01
Copper							
Cyanide	BDY					1.30E-10	1.30E-10
Endrin	CNS					1.55E-10	1.55E-10
Lead							
Manganese	CNS	CNS		1.91E-01		7.31E-08	1.91E-01
Mercury	K	CNS		8.82E-05		2.73E-07	8.85E-05
Molybdenum	U					2.76E-08	2.76E-08
Nickel	BDY					1.99E-08	1.99E-08
Selenium	BDY					5.84E-09	5.84E-09
Silver	S					1.32E-07	1.32E-07
Tetrachlordibenzo-p-dioxin							
Thallium	NO					3.46E-07	3.46E-07
Thorium							
Uranium	K					2.75E-06	2.75E-06
Vanadium						4.26E-08	4.26E-08
Zinc	B					4.60E-08	4.60E-08
Total Hazard Index			NC	1.07E+00	4.73E-06	4.33E-06	1.07E+00

Total – Liver	8.50E-01
Total – Fetus	2.38E-02
Total – CVS	2.27E-08
Total – Kidney	3.09E-06
Total – Respiratory	5.34E-04
Total – CNS	1.91E-01
Total – Blood	4.60E-08
Total – Whole Body	4.94E-06
Total – Skin	3.78E-07
Total – Testis	2.61E-08
Total – Urine	2.76E-08
Total – NO	4.05E-07

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – No data available
NO – None observed, T – Testis
Note:
NC – Not calculated, incomplete pathway

TABLE I.IV-5
HAZARD QUOTIENTS FOR THE OFF-PROPERTY RESIDENT FARM CHILD (RME), FUTURE LAND USE WITH FEDERAL OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY				1.10E-05	7.80E-07	1.18E-05
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S					9.39E-07	9.39E-07
Barium	CVS	F		6.67E-02		7.81E-08	6.67E-02
Beryllium	NO					5.73E-09	5.73E-09
Boron	T	R		1.49E-03		1.66E-07	1.49E-03
Cadmium	K				1.09E-22	3.74E-07	3.74E-07
Carbazole							
Chromium	NO					3.05E-07	3.05E-07
Cobalt	CVS	L		2.38E+00		2.73E-08	2.38E+00
Copper							
Cyanide	BDY					5.27E-10	5.27E-10
Endrin	CNS					7.27E-10	7.27E-10
Lead							
Manganese	CNS	CNS		5.35E-01		3.45E-07	5.35E-01
Mercury	K	CNS		2.47E-04		5.32E-07	2.48E-04
Molybdenum	U					1.42E-07	1.42E-07
Nickel	BDY					9.29E-08	9.29E-08
Selenium	BDY					3.36E-08	3.36E-08
Silver	S					1.26E-06	1.26E-06
Tetrachlordibenzo-p-dioxin							
Thallium	NO					1.18E-06	1.18E-06
Thorium							
Uranium	K					1.43E-05	1.43E-05
Vanadium						1.56E-07	1.56E-07
Zinc	B					1.98E-07	1.98E-07
Total Hazard Index			NC	2.98E+00	1.10E-05	2.10E-05	2.98E+00

Total – Liver	2.38E+00
Total – Fetus	6.67E-02
Total – CVS	1.05E-07
Total – Kidney	1.53E-05
Total – Respiratory	1.49E-03
Total – CNS	5.35E-01
Total – Blood	1.98E-07
Total – Whole Body	1.19E-05
Total – Skin	2.20E-06
Total – Testis	1.66E-07
Total – Urine	1.42E-07
Total – NO	1.49E-06

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – No data available
T – Testis, NO – None observed

Note:
NC – Not calculated, incomplete pathway

TABLE I.IV-7
HAZARD QUOTIENTS FOR THE ON-PROPERTY RESIDENT FARM ADULT (RME) (INGESTS GMA WATER), FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY		5.40E-01		8.49E-02	1.82E-01	8.07E-01
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S		7.63E-01			1.34E-01	8.97E-01
Barium	CVS	F	1.95E-02	5.23E-02		2.51E-02	9.70E-02
Beryllium	NO		7.64E-02			6.96E-04	7.71E-02
Boron	T	R	1.33E-01	2.78E-03		2.63E+00	2.77E+00
Cadmium	K		1.08E-01		7.89E-19	6.42E-01	7.50E-01
Carbazole							
Chromium	NO		3.78E-02			3.92E-02	7.70E-02
Cobalt	CVS	L	1.45E-03	1.65E+00		9.21E-03	1.66E+00
Copper			2.64E-04				2.64E-04
Cyanide	BDY		1.48E-04			2.97E-08	1.48E-04
Endrin	CNS					2.05E-05	2.05E-05
Lead							
Manganese	CNS	CNS	4.41E-01	3.76E-01		2.92E-01	1.11E+00
Mercury	K	CNS	1.05E-01	4.01E-04		8.45E+00	8.55E+00
Molybdenum	U		1.19E-02			3.35E-01	3.47E-01
Nickel	BDY		5.73E-03			6.49E-02	7.06E-02
Selenium	BDY		4.07E-03			8.16E-03	1.22E-02
Silver	S		8.48E-03			2.15E+00	2.16E+00
Tetrachlorodibenzo-p-dioxin							
Thallium	NO		1.19E-01			2.42E-01	3.60E-01
Thorium							
Uranium	K					2.75E-06	2.75E-06
Vanadium			2.90E-02			1.16E-02	4.06E-02
Zinc	B		6.59E-03			2.39E+00	2.40E+00
Total Hazard Index			2.41E+00	2.08E+00	8.49E-02	1.76E+01	2.22E+01

Total – Liver	1.65E+00
Total – Fetus	5.23E-02
Total – CVS	5.53E-02
Total – Kidney	9.30E+00
Total – Respiratory	2.78E-03
Total – CNS	1.11E+00
Total – Blood	2.40E+00
Total – Whole Body	8.90E-01
Total – Skin	3.06E+00
Total – Testis	2.77E+00
Total – Urine	3.47E-01
Total – NO	5.14E-01

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – No data available
T – Testis, NO – None observed
Note:
NC – Note calculated, incomplete pathway
GMA – Great Miami Acquifer

TABLE I.IV-6
HAZARD QUOTIENTS FOR THE ON-PROPERTY RESIDENT FARM ADULT (RME) (INGESTS PGW), FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY		5.40E-01			1.82E-01	7.22E-01
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S		7.63E-01			1.34E-01	8.97E-01
Barium	CVS	F	1.95E-02	5.23E-02		2.51E-02	9.70E-02
Beryllium	NO		7.64E-02			6.96E-04	7.71E-02
Boron	T	R	1.33E-01	2.78E-03		2.63E+00	2.77E+00
Cadmium	K		1.08E-01			6.42E-01	7.50E-01
Carbazole							
Chromium	NO		3.78E-02			3.92E-02	7.70E-02
Cobalt	CVS	L	1.45E-03	1.65E+00		9.21E-03	1.66E+00
Copper			2.64E-04				2.64E-04
Cyanide	BDY		1.48E-04			2.97E-08	1.48E-04
Endrin	CNS					2.05E-05	2.05E-05
Lead							
Manganese	CNS	CNS	4.41E-01	3.76E-01		2.92E-01	1.11E+00
Mercury	K	CNS	1.05E-01	4.01E-04		8.45E+00	8.55E+00
Molybdenum	U		1.19E-02			3.35E-01	3.47E-01
Nickel	BDY		5.73E-03			6.49E-02	7.06E-02
Selenium	BDY		4.07E-03			8.16E-03	1.22E-02
Silver	S		8.48E-03			2.15E+00	2.16E+00
Tetrachlorodibenzo-p-dioxin							
Thallium	NO		1.19E-01			2.42E-01	3.60E-01
Thorium							
Uranium	K					2.75E-06	2.75E-06
Vanadium			2.90E-02			1.16E-02	4.06E-02
Zinc	B		6.59E-03			2.39E+00	2.40E+00
Total Hazard Index			2.41E+00	2.08E+00	NC	1.76E+01	2.21E+01

Total – Liver	1.65E+00
Total – Fetus	5.23E-02
Total – CVS	5.53E-02
Total – Kidney	9.30E+00
Total – Respiratory	2.78E-03
Total – CNS	1.11E+00
Total – Blood	2.40E+00
Total – Whole Body	8.05E-01
Total – Skin	3.06E+00
Total – Testis	2.77E+00
Total – Urine	3.47E-01
Total – NO	5.14E-01

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – No data available
T – Testis, NO – None observed

Note:
NC – Not Calculated, incomplete pathway
PGW – Perched Groundwater

TABLE I.IV-9
HAZARD QUOTIENTS FOR THE OFF-PROPERTY RESIDENT FARM ADULT (RME), FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY				4.73E-06	1.89E-07	4.92E-06
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S					2.46E-07	2.46E-07
Barium	CVS	F		2.38E-02		1.63E-08	2.38E-02
Beryllium	NO					1.48E-09	1.48E-09
Boron	T	R		5.34E-04		2.61E-08	5.34E-04
Cadmium	K				4.68E-23	6.43E-08	6.43E-08
Carbazole							
Chromium	NO					5.79E-08	5.79E-08
Cobalt	CVS	L		8.50E-01		6.43E-09	8.50E-01
Copper							
Cyanide	BDY					1.30E-10	1.30E-10
Endrin	CNS					1.55E-10	1.55E-10
Lead							
Manganese	CNS	CNS		1.91E-01		7.31E-08	1.91E-01
Mercury	K	CNS		8.82E-05		2.73E-07	8.85E-05
Molybdenum	U					2.76E-08	2.76E-08
Nickel	BDY					1.99E-08	1.99E-08
Selenium	BDY					5.84E-09	5.84E-09
Silver	S					1.32E-07	1.32E-07
Tetrachlordibenzo-p-dioxin							
Thallium	NO					3.46E-07	3.46E-07
Thorium							
Uranium	K					2.75E-06	2.75E-06
Vanadium						4.26E-08	4.26E-08
Zinc	B					4.60E-08	4.60E-08
Total Hazard Index			NC	1.07E+00	4.73E-06	4.33E-06	1.07E+00

Total – Liver	8.50E-01
Total – Fetus	2.38E-02
Total – CVS	2.27E-08
Total – Kidney	3.09E-06
Total – Respiratory	5.34E-04
Total – CNS	1.91E-01
Total – Blood	4.60E-08
Total – Whole Body	4.94E-06
Total – Skin	3.78E-07
Total – Testis	2.61E-08
Total – Urine	2.76E-08
Total – NO	4.05E-07

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – No data available
T – Testis, NO – None observed

Note:
NC – Not calculated, incomplete pathway

TABLE I.IV-8
HAZARD QUOTIENTS FOR THE ON-PROPERTY RESIDENT FARM CHILD (RME)
FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY		1.49E+00		1.98E-01	7.47E-01	2.44E+00
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S		3.87E+00			4.16E-01	4.28E+00
Barium	CVS	F	8.31E-02	1.47E-01		2.02E-01	4.32E-01
Beryllium	NO		1.32E-01			2.48E-03	1.35E-01
Boron	T	R	2.79E-01	7.79E-03		2.02E+01	2.05E+01
Cadmium	K		2.27E-01		1.84E-18	5.09E+00	5.32E+00
Carbazole							
Chromium	NO		1.40E-01			2.38E-01	3.78E-01
Cobalt	CVS	L	5.39E-03	4.63E+00		3.96E-02	4.67E+00
Copper			4.29E-04				4.29E-04
Cyanide	BDY		7.67E-04			2.00E-07	7.67E-04
Endrin	CNS					9.94E-05	9.94E-05
Lead							
Manganese	CNS	CNS	8.51E-01	1.05E+00		1.95E+00	3.86E+00
Mercury	K	CNS	2.03E-01	1.12E-03		1.59E+01	1.61E+01
Molybdenum	U		4.23E-02			1.48E+00	1.52E+00
Nickel	BDY		2.69E-02			3.14E-01	3.41E-01
Selenium	BDY		1.70E-02			4.91E-02	6.61E-02
Silver	S		4.40E-02			2.18E+01	2.19E+01
Tetrachlordibenzo-p-dioxin							
Thallium	NO		4.89E-01			7.91E-01	1.28E+00
Thorium							
Uranium	K					1.43E-05	1.43E-05
Vanadium			1.10E-01			3.20E-02	1.42E-01
Zinc	B		2.10E-02			1.03E+01	1.03E+01
Total Hazard Index			8.03E+00	5.84E+00	1.98E-01	7.96E+01	9.36E+01

Total - Liver	4.63E+00
Total - Fetus	1.47E-01
Total - CVS	3.30E-01
Total - Kidney	2.14E+01
Total - Respiratory	7.79E-03
Total - CNS	3.86E+00
Total - Blood	1.03E+01
Total - Whole Body	2.84E+00
Total - Skin	2.61E+01
Total - Testis	2.05E+01
Total - Urine	1.52E+00
Total - NO	1.79E+00

B - Blood, CNS - Central Nervous System, CVS - Cardiovascular System,
F - Fetus, K - Kidney, L - Liver, R - Respiratory System, S - Skin,
U - Urine, BDY - Whole Body, ND - No data available
T - Testis, NO - None observed
Note:
NC - Not calculated, incomplete pathway

TABLE I.IV-10
HAZARD QUOTIENTS FOR THE OFF-PROPERTY RESIDENT FARM CHILD (RME)
FUTURE LAND USE WITHOUT FEDERAL OWNERSHIP

Chemical	Target Organs		Media				Total
	Oral	Inhalation	Soil	Air	Water	Food	
2-Methylnaphthalene							
4,4-DDE							
Antimony	BDY				1.10E-05	7.80E-07	1.18E-05
Aroclor-1221							
Aroclor-1248							
Aroclor-1254							
Aroclor-1260							
Arsenic	S					9.39E-07	9.39E-07
Barium	CVS	F		6.67E-02		7.81E-08	6.67E-02
Beryllium	NO					5.73E-09	5.73E-09
Boron	T	R		1.49E-03		1.66E-07	1.49E-03
Cadmium	K				1.09E-22	3.74E-07	3.74E-07
Carbazole							
Chromium	NO					3.05E-07	3.05E-07
Cobalt	CVS	L		2.38E+00		2.73E-08	2.38E+00
Copper							
Cyanide	BDY					5.27E-10	5.27E-10
Endrin	CNS					7.27E-10	7.27E-10
Lead							
Manganese	CNS	CNS		5.35E-01		3.45E-07	5.35E-01
Mercury	K	CNS		2.47E-04		5.32E-07	2.48E-04
Molybdenum	U					1.42E-07	1.42E-07
Nickel	BDY					9.29E-08	9.29E-08
Selenium	BDY					3.36E-08	3.36E-08
Silver	S					1.26E-06	1.26E-06
Tetrachlordibenzo-p-dioxin							
Thallium	NO					1.18E-06	1.18E-06
Thorium							
Uranium	K					1.43E-05	1.43E-05
Vanadium						1.56E-07	1.56E-07
Zinc	B					1.98E-07	1.98E-07
Total Hazard Index			NC	2.98E+00	1.10E-05	2.10E-05	2.98E+00

Total – Liver	2.38E+00
Total – Fetus	6.67E-02
Total – CVS	1.05E-07
Total – Kidney	1.53E-05
Total – Respiratory	1.49E-03
Total – CNS	5.35E-01
Total – Blood	1.98E-07
Total – Whole Body	1.19E-05
Total – Skin	2.20E-06
Total – Testis	1.66E-07
Total – Urine	1.42E-07
Total – NO	1.49E-06

B – Blood, CNS – Central Nervous System, CVS – Cardiovascular System,
F – Fetus, K – Kidney, L – Liver, R – Respiratory System, S – Skin,
U – Urine, BDY – Whole Body, ND – No data available
T – Testis, NO – None observed

Note:
NC – Not calculated, incomplete pathway

ATTACHMENT I.V
TECHNICAL REPORTS

ATTACHMENT I.V-1
SELECTION OF
GROUNDWATER RECEPTOR LOCATIONS

ATTACHMENT I.V-1
SELECTION OF
GROUNDWATER RECEPTOR LOCATIONS

For the specific locations of groundwater receptors, the U-238 and Tc-99 contour plots were reviewed and a limited number of potential receptor locations were selected for both on- and off-property receptors. These potential receptor locations were selected in areas where both U-238 and Tc-99 reached maximum values. COC concentrations with time were listed at each of these points. Then, to be conservative, a method was developed to determine both the location and the 10-year interval over which the greatest ILCR was estimated for an adult RME receptor. This receptor was assumed to ingest 2 liters of groundwater per day over a 70-year lifetime. For each 10-year interval of the groundwater modeling output, and for each potential receptor location, the ILCR was estimated for each modeled COC (which had an appropriate cancer slope factor). The resulting individual cancer risks were summed for each location over the 10-year interval. The single location where the RME receptor would experience the greatest total ILCR (over each 70 or 1000 years of groundwater modeling output) was chosen as the representative receptor location for each scenario. One receptor location was selected for the maximum on-property risk, and one for the maximum off-property risk.

This process is presented in the following tables and figures.

70–YEAR OFF–PROPERTY GROUNDWATER – ILCR FOR RME RECEPTOR

INTAKE EQUATIONS

Chemical Intake Equation = $\frac{Cw \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2	l/day
EF	Exposure frequency	350	days/year
ED	Exposure duration	70	year
FI	Fractional intake of chemicals	1	(unitless)
Cw	Concentration of chemicals in groundwater		Attachment III
BW	Body weight	70	kg
AT	Average time for chemicals (lifetime)	25550	days

Radionuclide Intake Equation = $Cw \times EF \times ED \times FI \times IR$

IR	Ingestion rate of groundwater (RAGS, 1989)	2	l/day
EF	Exposure frequency	350	days/year
ED	Exposure duration	70	year
FI	Fractional intake of radionuclides	1	(unitless)
Cw	Concentration of radionuclides in groundwater		Attachment III

CANCER SLOPE FACTORS (CSF) & RADIONUCLIDE SPECIFIC CONCENTRATIONS (CR)

Chemical	CSF	CR
Aroclor–1221	7.7E+00 1/mg/kg–day	–
Antimony	See note 1	–
Cadmium	See note 1	–
NP237	2.2E–10 risk/pCi	7.05E+02 pCi/ug
TC–99	1.3E–12 risk/pCi	1.70E+04 pCi/ug
U–234	1.6E–11 risk/pCi	6.22E+03 pCi/ug
U–235	1.6E–11 risk/pCi	2.16E+00 pCi/ug
U–236	1.5E–11 risk/pCi	6.34E+01 pCi/ug
U–238	2.8E–11 risk/pCi	3.36E–01 pCi/ug

Note 1: EPA Cancer Slope factor is not available.

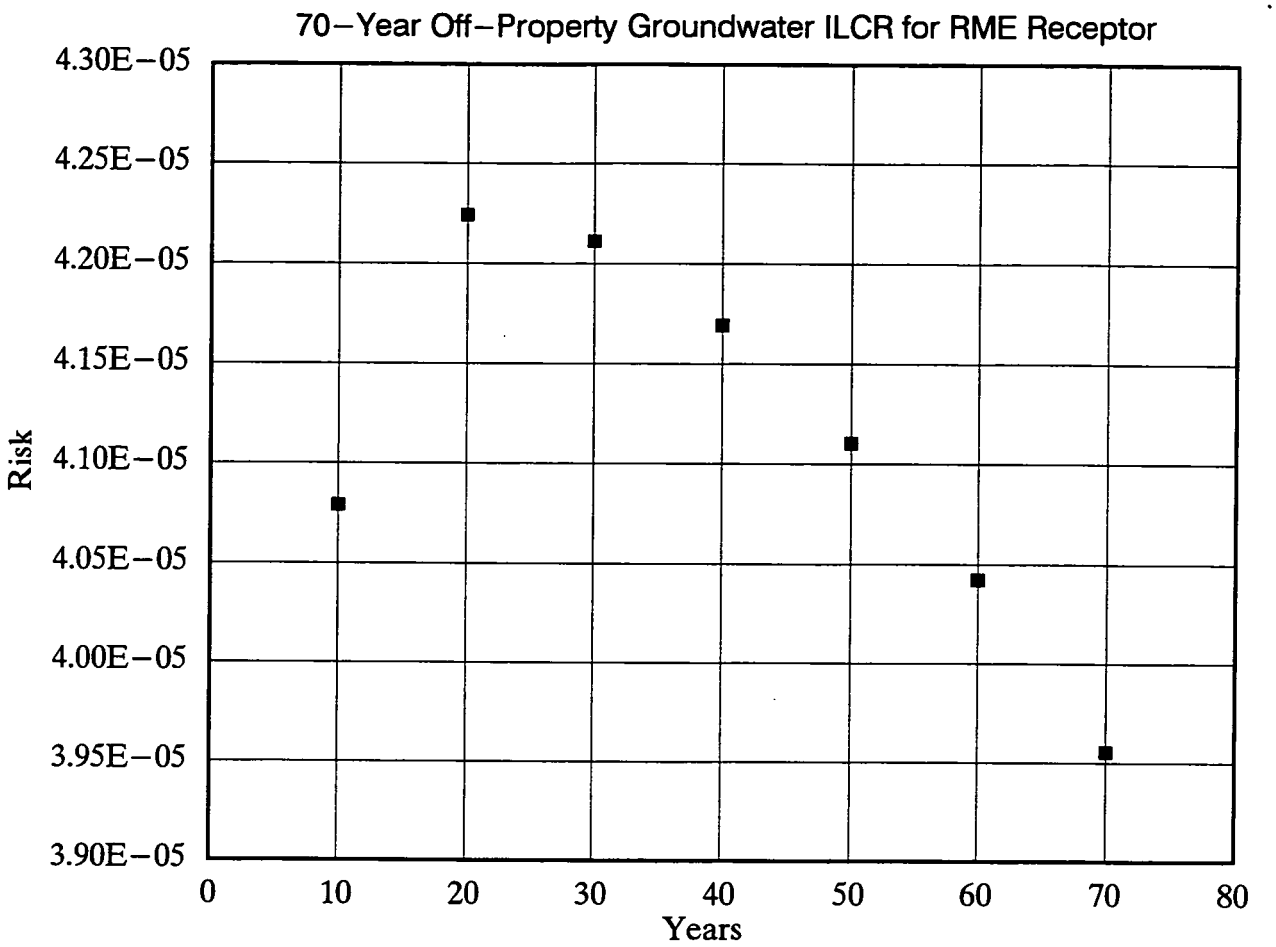
70–YEAR OFF–PROPERTY GROUNDWATER – ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor–1221	NP–237	TC–99	U–234	U–235	U–236	U–238	Total Receptor	10 Year Interval	Off–Property Max 10 Year Risk
40	40	10	0	1.5E–17	1.4E–05	8.0E–06	2.1E–07	8.2E–08	8.4E–06	3.1E–05		
70	60	10	0	2.8E–30	7.6E–09	1.2E–19	3.3E–21	1.3E–21	1.3E–19	7.6E–09		
35	**45**	**10**	**0**	**3.4E–11**	**2.4E–05**	**8.1E–06**	**2.2E–07**	**8.4E–08**	**8.5E–06**	**4.1E–05**	**10**	**4.1E–05**
40	40	20	0	1.2E–13	1.9E–05	7.0E–06	1.9E–07	7.2E–08	7.4E–06	3.4E–05		
70	60	20	0	2.8E–24	9.6E–08	2.5E–14	6.7E–16	2.6E–16	2.7E–14	9.6E–08		
35	**45**	**20**	**0**	**2.9E–09**	**2.6E–05**	**7.7E–06**	**2.1E–07**	**8.0E–08**	**8.1E–06**	**4.2E–05**	**20**	**4.2E–05**
40	40	30	0	1.2E–11	2.0E–05	6.4E–06	1.7E–07	6.6E–08	6.7E–06	3.3E–05		
70	60	30	0	6.1E–21	4.6E–07	1.2E–11	3.1E–13	1.2E–13	1.2E–11	4.6E–07		
35	**45**	**30**	**5.6E–48**	**2.1E–08**	**2.6E–05**	**7.6E–06**	**2.0E–07**	**7.8E–08**	**7.9E–06**	**4.2E–05**	**30**	**4.2E–05**
40	40	40	0	2.0E–10	2.0E–05	6.1E–06	1.6E–07	6.3E–08	6.4E–06	3.3E–05		
70	60	40	0	9.5E–19	1.4E–06	4.3E–10	1.1E–11	4.4E–12	4.5E–10	1.4E–06		
35	**45**	**40**	**3.3E–43**	**6.0E–08**	**2.6E–05**	**7.3E–06**	**2.0E–07**	**7.5E–08**	**7.7E–06**	**4.2E–05**	**40**	**4.2E–05**
40	40	50	0	1.3E–09	2.0E–05	6.0E–06	1.6E–07	6.1E–08	6.3E–06	3.2E–05		
70	60	50	0	3.5E–17	2.5E–06	4.4E–09	1.2E–10	4.5E–11	4.6E–09	2.6E–06		
35	**45**	**50**	**1.5E–39**	**1.1E–07**	**2.6E–05**	**7.0E–06**	**1.9E–07**	**7.2E–08**	**7.4E–06**	**4.1E–05**	**50**	**4.1E–05**
40	40	60	2.4E–41	4.6E–09	2.0E–05	5.9E–06	1.6E–07	6.1E–08	6.2E–06	3.2E–05		
70	60	60	0	5.4E–16	3.3E–06	2.1E–08	5.6E–10	2.2E–10	2.2E–08	3.3E–06		
35	**45**	**60**	**1.2E–36**	**1.7E–07**	**2.6E–05**	**6.7E–06**	**1.8E–07**	**6.9E–08**	**7.0E–06**	**4.0E–05**	**60**	**4.0E–05**
40	40	70	1.2E–38	1.2E–08	2.0E–05	5.8E–06	1.5E–07	5.9E–08	6.0E–06	3.2E–05		
70	60	70	0	4.6E–15	3.6E–06	6.2E–08	1.6E–09	6.4E–10	6.5E–08	3.7E–06		
35	**45**	**70**	**3.2E–34**	**2.2E–07**	**2.6E–05**	**6.2E–06**	**1.7E–07**	**6.4E–08**	**6.5E–06**	**4.0E–05**	**70**	**4.0E–05**

70 Year Maximum Risk – 4.2E–05

10 year intervals and receptor location used are indicated by bold lettering.


70-Year Off-Property Groundwater ILCR for RME Receptor
4.30E-05
4.25E-05
4.20E-05
4.15E-05
4.10E-05
4.05E-05
4.00E-05
3.95E-05
3.90E-05
Risk
0
10
20
30
40
50
60
70
80
Years

Average Groundwater Contaminant Concentrations – Off–Property (70 Years)

IX	IY	Time (yr)	Aroclor–122 PPB=ug/l	Antimony PPB=ug/l	Cadmium PPB=ug/l	NP–237 PPB=ug/l	TC–99 PPB=ug/l	U234 PPB=ug/l	U235 PPB=ug/l	U236 PPB=ug/l	U238 PPB=ug/l
35	45	10	0	9.03E–15	0	4.51E–09	2.20E–02	1.67E–03	1.28E–01	1.79E–03	1.85E+01
35	45	20	0	1.20E–11	0	3.87E–07	2.41E–02	1.59E–03	1.21E–01	1.71E–03	1.76E+01
35	45	30	2.66E–44	6.84E–10	6.07E–41	2.74E–06	2.43E–02	1.55E–03	1.19E–01	1.67E–03	1.72E+01
35	45	40	1.55E–39	1.08E–08	3.36E–36	7.84E–06	2.43E–02	1.51E–03	1.15E–01	1.62E–03	1.67E+01
35	45	50	6.98E–36	8.52E–08	1.43E–32	1.47E–05	2.43E–02	1.44E–03	1.10E–01	1.55E–03	1.60E+01
35	45	60	5.89E–33	4.31E–07	1.14E–29	2.19E–05	2.43E–02	1.37E–03	1.05E–01	1.47E–03	1.52E+01
35	45	70	1.54E–30	1.61E–06	2.84E–27	2.85E–05	2.43E–02	1.28E–03	9.80E–02	1.38E–03	1.42E+01
Ave Conc @ (35,45)			2.21E–31	3.05E–07	4.07E–28	1.09E–05	2.39E–02	1.49E–03	1.14E–01	1.60E–03	1.65E+01

1000-YEAR OFF-PROPERTY GROUNDWATER - ILCR FOR RME RECEPTOR

INTAKE EQUATIONS

Chemical Intake Equation = $\frac{Cw \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2	l/day
EF	Exposure frequency	350	days/year
ED	Exposure duration	70	year
FI	Fractional intake of chemicals	1	(unitless)
Cw	Concentration of chemicals in groundwater		Attachment I & II
BW	Body weight	70	kg
AT	Average time for chemicals (lifetime)	25550	days

Radionuclide Intake Equation = Cw X EF X ED X FI X IR

IR	Ingestion rate of groundwater (RAGS, 1989)	2	l/day
EF	Exposure frequency	350	days/year
ED	Exposure duration	70	year
FI	Fractional intake of radionuclides	1	(unitless)
Cw	Concentration of radionuclides in groundwater		Attachment I & II

CANCER SLOPE FACTORS (CSF) & RADIONUCLIDE SPECIFIC CONCENTRATIONS (CR)

Chemical	CSF	CR
Aroclor-1221	7.7E+00 1/mg/kg-day	-
Antimony	See note 1	-
Cadmium	See note 1	-
NP237	2.2E-10 risk/pCi	7.05E+02 pCi/ug
TC-99	1.3E-12 risk/pCi	1.70E+04 pCi/ug
U-234	1.6E-11 risk/pCi	6.22E+03 pCi/ug
U-235	1.6E-11 risk/pCi	2.16E+00 pCi/ug
U-236	1.5E-11 risk/pCi	6.34E+01 pCi/ug
U-238	2.8E-11 risk/pCi	3.36E-01 pCi/ug

Note 1: EPA Cancer Slope factor is not available.

1000–YEAR OFF–PROPERTY GROUNDWATER – ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor–1221	NP–237	TC–99	U–234	U–235	U–236	U–238	Total Receptor	10 Year Interval	Off–Property Max 10 Year Risk
35	45	10	0	1.2E–10	7.4E–05	8.7E–06	2.3E–07	8.9E–08	9.1E–06	9.2E–05		
40	40	10	0	5.3E–17	4.6E–05	8.1E–06	2.1E–07	8.3E–08	8.4E–06	6.3E–05		
70	60	10	0	1.0E–29	2.4E–08	6.6E–20	1.8E–21	6.8E–22	6.9E–20	2.4E–08	10	9.2E–05
35	45	20	0	1.0E–08	7.7E–05	1.3E–05	3.4E–07	1.3E–07	1.3E–05	1.0E–04		
40	40	20	0	4.3E–13	5.8E–05	7.2E–06	1.9E–07	7.4E–08	7.6E–06	7.3E–05		
70	60	20	0	1.0E–23	1.9E–07	2.3E–14	6.2E–16	2.4E–16	2.4E–14	1.9E–07	20	1.0E–04
35	45	30	5.6E–48	7.4E–08	7.7E–05	1.7E–05	4.6E–07	1.8E–07	1.8E–05	1.1E–04		
40	40	30	0	4.3E–11	5.9E–05	7.6E–06	2.0E–07	7.8E–08	7.9E–06	7.4E–05		
70	60	30	0	2.2E–20	5.9E–07	1.0E–11	2.8E–13	1.1E–13	1.1E–11	5.9E–07	30	1.1E–04
35	45	40	3.3E–43	2.1E–07	7.7E–05	2.0E–05	5.3E–07	2.0E–07	2.1E–05	1.2E–04		
40	40	40	0	7.0E–10	5.9E–05	9.5E–06	2.5E–07	9.7E–08	9.9E–06	7.9E–05		
70	60	40	0	3.4E–18	1.5E–06	3.9E–10	1.0E–11	4.0E–12	4.1E–10	1.5E–06	40	1.2E–04
35	**45**	**50**	**1.5E–39**	**4.0E–07**	**7.7E–05**	**2.1E–05**	**5.5E–07**	**2.1E–07**	**2.2E–05**	**1.2E–04**		
40	40	50	0	4.5E–09	5.9E–05	1.2E–05	3.1E–07	1.2E–07	1.2E–05	8.3E–05		
70	60	50	0	1.3E–16	2.7E–06	4.1E–09	1.1E–10	4.2E–11	4.3E–09	2.7E–06	**50**	**1.2E–04**
35	**45**	**60**	**1.2E–36**	**5.9E–07**	**7.7E–05**	**2.1E–05**	**5.6E–07**	**2.2E–07**	**2.2E–05**	**1.2E–04**		
40	40	60	2.4E–41	1.6E–08	5.9E–05	1.4E–05	3.6E–07	1.4E–07	1.4E–05	8.7E–05		
70	60	60	0	1.9E–15	3.4E–06	2.0E–08	5.4E–10	2.1E–10	2.1E–08	3.4E–06	**60**	**1.2E–04**
35	**45**	**70**	**3.2E–34**	**7.7E–07**	**7.8E–05**	**2.1E–05**	**5.6E–07**	**2.2E–07**	**2.2E–05**	**1.2E–04**		
40	40	70	1.2E–38	4.1E–08	5.9E–05	1.5E–05	3.9E–07	1.5E–07	1.5E–05	9.0E–05		
70	60	70	0	1.6E–14	3.7E–06	6.1E–08	1.6E–09	6.2E–10	6.4E–08	3.8E–06	**70**	**1.2E–04**
35	**45**	**80**	**3.5E–32**	**9.2E–07**	**7.8E–05**	**2.1E–05**	**5.5E–07**	**2.1E–07**	**2.2E–05**	**1.2E–04**		
40	40	80	2.4E–36	8.3E–08	5.9E–05	1.5E–05	4.1E–07	1.6E–07	1.6E–05	9.1E–05		
70	60	80	7.3E–41	9.0E–14	3.8E–06	1.3E–07	3.5E–09	1.4E–09	1.4E–07	4.1E–06	**80**	**1.2E–04**
35	**45**	**90**	**2.0E–30**	**1.0E–06**	**7.8E–05**	**2.0E–05**	**5.4E–07**	**2.1E–07**	**2.1E–05**	**1.2E–04**		
40	40	90	2.3E–34	1.4E–07	5.9E–05	1.6E–05	4.2E–07	1.6E–07	1.7E–05	9.2E–05		
70	60	90	1.7E–38	3.6E–13	3.8E–06	2.3E–07	6.1E–09	2.3E–09	2.4E–07	4.3E–06	**90**	**1.2E–04**
35	**45**	**100**	**6.7E–29**	**1.1E–06**	**7.7E–05**	**2.0E–05**	**5.3E–07**	**2.0E–07**	**2.1E–05**	**1.2E–04**		
40	40	100	1.3E–32	2.1E–07	5.9E–05	1.6E–05	4.2E–07	1.6E–07	1.7E–05	9.2E–05		
70	60	100	1.9E–36	1.1E–12	3.6E–06	3.4E–07	9.0E–09	3.5E–09	3.5E–07	4.3E–06	**100**	**1.2E–04**
35	**45**	**110**	**1.5E–27**	**1.2E–06**	**7.7E–05**	**1.9E–05**	**5.2E–07**	**2.0E–07**	**2.0E–05**	**1.2E–04**		
40	40	110	4.3E–31	2.9E–07	5.9E–05	1.6E–05	4.2E–07	1.6E–07	1.7E–05	9.2E–05		
70	60	110	1.3E–34	3.0E–12	2.7E–06	4.5E–07	1.2E–08	4.7E–09	4.7E–07	3.6E–06	**110**	**1.2E–04**
35	45	120	2.2E–26	1.3E–06	7.7E–05	1.9E–05	5.1E–07	2.0E–07	2.0E–05	1.2E–04		
40	40	120	1.0E–29	3.7E–07	5.9E–05	1.6E–05	4.1E–07	1.6E–07	1.6E–05	9.2E–05		
70	60	120	5.4E–33	6.9E–12	1.5E–06	5.7E–07	1.5E–08	5.9E–09	6.0E–07	2.7E–06	120	1.2E–04

1000–YEAR OFF–PROPERTY GROUNDWATER – ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor–1221	NP–237	TC–99	U–234	U–235	U–236	U–238	Total Receptor	10 Year Interval	Off–Property Max 10 Year Risk
35	45	130	2.6E–25	1.3E–06	7.7E–05	1.9E–05	5.0E–07	1.9E–07	2.0E–05	1.2E–04		
40	40	130	1.7E–28	4.5E–07	5.9E–05	1.5E–05	4.1E–07	1.6E–07	1.6E–05	9.1E–05		
70	60	130	1.5E–31	1.4E–11	8.1E–07	7.0E–07	1.8E–08	7.1E–09	7.3E–07	2.3E–06	130	1.2E–04
35	45	140	2.3E–24	1.4E–06	7.7E–05	1.9E–05	4.9E–07	1.9E–07	1.9E–05	1.2E–04		
40	40	140	2.2E–27	5.3E–07	5.9E–05	1.5E–05	4.0E–07	1.5E–07	1.6E–05	9.1E–05		
70	60	140	3.2E–30	2.6E–11	5.0E–07	8.2E–07	2.2E–08	8.4E–09	8.6E–07	2.2E–06	140	1.2E–04
35	45	150	1.7E–23	1.4E–06	7.7E–05	1.8E–05	4.9E–07	1.9E–07	1.9E–05	1.2E–04		
40	40	150	2.2E–26	6.1E–07	5.9E–05	1.5E–05	3.9E–07	1.5E–07	1.5E–05	9.0E–05		
70	60	150	5.1E–29	4.3E–11	4.1E–07	9.5E–07	2.5E–08	9.8E–09	1.0E–06	2.4E–06	150	1.2E–04
35	45	160	1.0E–22	1.4E–06	7.7E–05	1.8E–05	4.8E–07	1.9E–07	1.9E–05	1.2E–04		
40	40	160	1.8E–25	6.7E–07	5.9E–05	1.4E–05	3.8E–07	1.5E–07	1.5E–05	9.0E–05		
70	60	160	6.3E–28	6.8E–11	3.9E–07	1.1E–06	2.9E–08	1.1E–08	1.1E–06	2.7E–06	160	1.2E–04
35	45	170	5.3E–22	1.4E–06	7.7E–05	1.8E–05	4.8E–07	1.9E–07	1.9E–05	1.2E–04		
40	40	170	1.3E–24	7.3E–07	5.9E–05	1.4E–05	3.8E–07	1.5E–07	1.5E–05	8.9E–05		
70	60	170	6.3E–27	1.0E–10	3.8E–07	1.2E–06	3.3E–08	1.3E–08	1.3E–06	2.9E–06	170	1.2E–04
35	45	180	2.4E–21	1.5E–06	7.7E–05	1.8E–05	4.8E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	180	7.7E–24	7.9E–07	5.9E–05	1.4E–05	3.7E–07	1.5E–07	1.5E–05	8.9E–05		
70	60	180	5.2E–26	1.5E–10	3.8E–07	1.4E–06	3.6E–08	1.4E–08	1.4E–06	3.2E–06	180	1.2E–04
35	45	190	9.6E–21	1.5E–06	7.7E–05	1.8E–05	4.8E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	190	4.0E–23	8.4E–07	5.9E–05	1.4E–05	3.7E–07	1.4E–07	1.5E–05	8.9E–05		
70	60	190	3.7E–25	2.0E–10	3.9E–07	1.5E–06	4.0E–08	1.5E–08	1.6E–06	3.5E–06	190	1.2E–04
35	45	200	3.4E–20	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	200	1.8E–22	8.8E–07	5.9E–05	1.4E–05	3.7E–07	1.4E–07	1.5E–05	8.9E–05		
70	60	200	2.2E–24	2.7E–10	4.0E–07	1.6E–06	4.3E–08	1.7E–08	1.7E–06	3.8E–06	200	1.2E–04
35	45	210	1.1E–19	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	210	7.5E–22	9.2E–07	5.9E–05	1.4E–05	3.7E–07	1.4E–07	1.4E–05	8.9E–05		
70	60	210	1.2E–23	3.5E–10	4.1E–07	1.7E–06	4.6E–08	1.8E–08	1.8E–06	4.0E–06	210	1.2E–04
35	45	220	3.3E–19	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	220	2.8E–21	9.5E–07	5.9E–05	1.4E–05	3.7E–07	1.4E–07	1.4E–05	8.9E–05		
70	60	220	5.7E–23	4.4E–10	4.2E–07	1.8E–06	4.9E–08	1.9E–08	1.9E–06	4.3E–06	220	1.2E–04
35	45	230	9.0E–19	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	230	9.5E–21	9.8E–07	5.9E–05	1.4E–05	3.6E–07	1.4E–07	1.4E–05	8.9E–05		
70	60	230	2.4E–22	5.4E–10	4.4E–07	1.9E–06	5.1E–08	2.0E–08	2.0E–06	4.4E–06	230	1.2E–04
35	45	240	2.3E–18	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	240	3.0E–20	1.0E–06	5.9E–05	1.4E–05	3.6E–07	1.4E–07	1.4E–05	8.9E–05		
70	60	240	9.5E–22	6.7E–10	4.6E–07	2.0E–06	5.3E–08	2.1E–08	2.1E–06	4.6E–06	240	1.2E–04
35	45	250	5.5E–18	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	250	8.7E–20	1.0E–06	5.9E–05	1.4E–05	3.6E–07	1.4E–07	1.4E–05	8.8E–05		
70	60	250	3.4E–21	8.2E–10	4.7E–07	2.1E–06	5.5E–08	2.1E–08	2.2E–06	4.8E–06	250	1.2E–04
35	45	260	1.3E–17	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	260	2.4E–19	1.0E–06	5.9E–05	1.4E–05	3.6E–07	1.4E–07	1.4E–05	8.8E–05		
70	60	260	1.1E–20	1.0E–09	4.9E–07	2.1E–06	5.6E–08	2.2E–08	2.2E–06	4.9E–06	260	1.2E–04

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1000-YEAR OFF-PROPERTY GROUNDWATER – ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor	10 Year Interval	Off-Property Max 10 Year Risk
35	45	270	2.7E-17	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	270	6.1E-19	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	270	3.4E-20	1.2E-09	5.0E-07	2.2E-06	5.7E-08	2.2E-08	2.3E-06	5.0E-06	270	1.2E-04
35	45	280	5.5E-17	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	280	1.5E-18	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	280	9.9E-20	1.5E-09	5.2E-07	2.2E-06	5.9E-08	2.3E-08	2.3E-06	5.1E-06	280	1.2E-04
35	45	290	1.1E-16	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	290	3.4E-18	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	290	2.7E-19	1.8E-09	5.3E-07	2.2E-06	5.9E-08	2.3E-08	2.3E-06	5.2E-06	290	1.2E-04
35	45	300	2.0E-16	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	300	7.4E-18	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	300	6.8E-19	2.3E-09	5.3E-07	2.3E-06	6.0E-08	2.3E-08	2.4E-06	5.3E-06	300	1.2E-04
35	45	310	3.6E-16	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	310	1.6E-17	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	310	1.6E-18	2.8E-09	5.3E-07	2.3E-06	6.1E-08	2.3E-08	2.4E-06	5.3E-06	310	1.2E-04
35	45	320	6.3E-16	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	320	3.1E-17	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	320	3.8E-18	3.5E-09	5.3E-07	2.3E-06	6.1E-08	2.4E-08	2.4E-06	5.4E-06	320	1.2E-04
35	45	330	1.1E-15	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	330	6.1E-17	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	330	8.4E-18	4.3E-09	5.3E-07	2.3E-06	6.2E-08	2.4E-08	2.4E-06	5.4E-06	330	1.2E-04
35	45	340	1.8E-15	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	340	1.1E-16	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	340	1.8E-17	5.3E-09	5.3E-07	2.3E-06	6.2E-08	2.4E-08	2.5E-06	5.4E-06	340	1.2E-04
35	45	350	2.8E-15	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	350	2.1E-16	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	350	3.6E-17	6.6E-09	5.3E-07	2.4E-06	6.2E-08	2.4E-08	2.5E-06	5.4E-06	350	1.2E-04
35	45	360	4.4E-15	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	360	3.6E-16	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	360	7.1E-17	8.0E-09	5.3E-07	2.4E-06	6.3E-08	2.4E-08	2.5E-06	5.5E-06	360	1.2E-04
35	45	370	6.7E-15	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	370	6.2E-16	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	370	1.4E-16	9.7E-09	5.2E-07	2.4E-06	6.3E-08	2.4E-08	2.5E-06	5.5E-06	370	1.2E-04
35	45	380	9.9E-15	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	380	1.0E-15	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	380	2.5E-16	1.2E-08	5.2E-07	2.4E-06	6.3E-08	2.4E-08	2.5E-06	5.5E-06	380	1.2E-04
35	45	390	1.4E-14	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	390	1.7E-15	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	390	4.5E-16	1.4E-08	5.1E-07	2.4E-06	6.3E-08	2.5E-08	2.5E-06	5.5E-06	390	1.2E-04
35	45	400	2.1E-14	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	400	2.7E-15	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	400	7.8E-16	1.6E-08	5.1E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	400	1.2E-04

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor	10 Year Interval	Off-Property Max 10 Year Risk
35	45	410	2.9E-14	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	410	4.2E-15	1.1E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	410	1.3E-15	1.9E-08	5.0E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	410	1.2E-04
35	45	420	4.0E-14	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	420	6.4E-15	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	420	2.2E-15	2.2E-08	5.0E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	420	1.2E-04
35	45	430	5.4E-14	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	430	9.5E-15	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	430	3.6E-15	2.6E-08	4.9E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	430	1.2E-04
35	45	440	7.3E-14	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	440	1.4E-14	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	440	5.7E-15	2.9E-08	4.9E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	440	1.2E-04
35	45	450	9.6E-14	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	450	2.0E-14	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	450	8.9E-15	3.3E-08	4.8E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	450	1.2E-04
35	45	460	1.3E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	460	2.8E-14	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	460	1.4E-14	3.7E-08	4.7E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	460	1.2E-04
35	45	470	1.6E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	470	4.0E-14	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	470	2.1E-14	4.2E-08	4.7E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	470	1.2E-04
35	45	480	2.1E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	480	5.5E-14	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	480	3.1E-14	4.6E-08	4.6E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	480	1.2E-04
35	45	490	2.6E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	490	7.5E-14	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	490	4.5E-14	5.1E-08	4.6E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	490	1.2E-04
35	45	500	3.2E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	500	1.0E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	500	6.4E-14	5.5E-08	4.5E-07	2.4E-06	6.4E-08	2.5E-08	2.5E-06	5.5E-06	500	1.2E-04
35	45	510	4.0E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	510	1.3E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	510	9.0E-14	6.0E-08	4.5E-07	2.4E-06	6.3E-08	2.4E-08	2.5E-06	5.5E-06	510	1.2E-04
35	45	520	4.9E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	520	1.8E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	520	1.3E-13	6.5E-08	4.4E-07	2.4E-06	6.3E-08	2.4E-08	2.5E-06	5.4E-06	520	1.2E-04
35	45	530	5.9E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	530	2.3E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	530	1.7E-13	7.0E-08	4.3E-07	2.3E-06	6.2E-08	2.4E-08	2.4E-06	5.4E-06	530	1.2E-04
35	45	540	7.1E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	540	2.9E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	540	2.4E-13	7.5E-08	4.3E-07	2.3E-06	6.1E-08	2.4E-08	2.4E-06	5.3E-06	540	1.2E-04

1000-YEAR OFF-PROPERTY GROUNDWATER - ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor	10 Year Interval	Off-Property Max 10 Year Risk
35	45	550	8.5E-13	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	550	3.7E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	550	3.2E-13	8.0E-08	4.2E-07	2.3E-06	6.1E-08	2.3E-08	2.4E-06	5.3E-06	550	1.2E-04
35	45	560	1.0E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	560	4.7E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	560	4.2E-13	8.4E-08	4.2E-07	2.3E-06	6.0E-08	2.3E-08	2.4E-06	5.2E-06	560	1.2E-04
35	45	570	1.2E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	570	5.9E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	570	5.6E-13	8.9E-08	4.2E-07	2.2E-06	5.9E-08	2.3E-08	2.3E-06	5.2E-06	570	1.2E-04
35	45	580	1.4E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	580	7.3E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	580	7.3E-13	9.3E-08	4.1E-07	2.2E-06	5.9E-08	2.3E-08	2.3E-06	5.1E-06	580	1.2E-04
35	45	590	1.6E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	590	8.9E-13	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	590	9.4E-13	9.8E-08	4.1E-07	2.2E-06	5.8E-08	2.3E-08	2.3E-06	5.1E-06	590	1.2E-04
35	45	600	1.9E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	600	1.1E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	600	1.2E-12	1.0E-07	4.0E-07	2.2E-06	5.8E-08	2.2E-08	2.3E-06	5.0E-06	600	1.2E-04
35	45	610	2.1E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	610	1.3E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	610	1.5E-12	1.1E-07	4.0E-07	2.2E-06	5.7E-08	2.2E-08	2.3E-06	5.0E-06	610	1.2E-04
35	45	620	2.4E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	620	1.6E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	620	1.9E-12	1.1E-07	4.0E-07	2.2E-06	5.7E-08	2.2E-08	2.3E-06	5.0E-06	620	1.2E-04
35	45	630	2.8E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	630	1.9E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	630	2.4E-12	1.2E-07	4.0E-07	2.1E-06	5.7E-08	2.2E-08	2.2E-06	5.0E-06	630	1.2E-04
35	45	640	3.1E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	640	2.2E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	640	3.0E-12	1.2E-07	3.9E-07	2.1E-06	5.7E-08	2.2E-08	2.2E-06	5.0E-06	640	1.2E-04
35	45	650	3.5E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	650	2.6E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	650	3.6E-12	1.2E-07	3.9E-07	2.1E-06	5.6E-08	2.2E-08	2.2E-06	4.9E-06	650	1.2E-04
35	45	660	3.9E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	660	3.1E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	660	4.5E-12	1.3E-07	3.9E-07	2.1E-06	5.6E-08	2.2E-08	2.2E-06	4.9E-06	660	1.2E-04
35	45	670	4.4E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	670	3.6E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	670	5.4E-12	1.3E-07	3.9E-07	2.1E-06	5.5E-08	2.1E-08	2.2E-06	4.8E-06	670	1.2E-04
35	45	680	4.8E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	680	4.2E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	680	6.5E-12	1.3E-07	3.9E-07	2.0E-06	5.4E-08	2.1E-08	2.1E-06	4.7E-06	680	1.2E-04

1000-YEAR OFF-PROPERTY GROUNDWATER - ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor	10 Year Interval	Off-Property Max 10 Year Risk
35	45	690	5.3E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	690	4.8E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	690	7.8E-12	1.4E-07	3.8E-07	2.0E-06	5.2E-08	2.0E-08	2.1E-06	4.6E-06	690	1.2E-04
35	45	700	5.9E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	700	5.5E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	700	9.3E-12	1.4E-07	3.8E-07	1.9E-06	5.1E-08	2.0E-08	2.0E-06	4.5E-06	700	1.2E-04
35	45	710	6.4E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	710	6.3E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	710	1.1E-11	1.4E-07	3.8E-07	1.8E-06	4.9E-08	1.9E-08	1.9E-06	4.4E-06	710	1.2E-04
35	45	720	7.0E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	720	7.2E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	720	1.3E-11	1.4E-07	3.8E-07	1.8E-06	4.7E-08	1.8E-08	1.9E-06	4.2E-06	720	1.2E-04
35	45	730	7.6E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	730	8.1E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	730	1.5E-11	1.5E-07	3.8E-07	1.7E-06	4.5E-08	1.8E-08	1.8E-06	4.1E-06	730	1.2E-04
35	45	740	8.3E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	740	9.2E-12	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	740	1.8E-11	1.5E-07	3.8E-07	1.7E-06	4.4E-08	1.7E-08	1.7E-06	4.0E-06	740	1.2E-04
35	45	750	9.0E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	750	1.0E-11	1.2E-06	5.9E-05	1.4E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	750	2.1E-11	1.5E-07	3.8E-07	1.6E-06	4.2E-08	1.6E-08	1.7E-06	3.8E-06	750	1.2E-04
35	45	760	9.7E-12	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	760	1.1E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	760	2.4E-11	1.5E-07	3.8E-07	1.5E-06	4.1E-08	1.6E-08	1.6E-06	3.7E-06	760	1.2E-04
35	45	770	1.0E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	770	1.3E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	770	2.7E-11	1.6E-07	3.8E-07	1.5E-06	4.0E-08	1.5E-08	1.6E-06	3.6E-06	770	1.2E-04
35	45	780	1.1E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	780	1.4E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	780	3.1E-11	1.6E-07	3.8E-07	1.5E-06	3.9E-08	1.5E-08	1.5E-06	3.6E-06	780	1.2E-04
35	45	790	1.2E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	790	1.6E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	790	3.6E-11	1.6E-07	3.8E-07	1.4E-06	3.8E-08	1.5E-08	1.5E-06	3.5E-06	790	1.2E-04
35	45	800	1.3E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	800	1.7E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	800	4.0E-11	1.6E-07	3.7E-07	1.4E-06	3.7E-08	1.4E-08	1.5E-06	3.4E-06	800	1.2E-04
35	45	810	1.3E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	810	1.9E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	810	4.6E-11	1.6E-07	3.7E-07	1.4E-06	3.6E-08	1.4E-08	1.4E-06	3.4E-06	810	1.2E-04
35	45	820	1.4E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	820	2.1E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	820	5.1E-11	1.6E-07	3.7E-07	1.3E-06	3.6E-08	1.4E-08	1.4E-06	3.3E-06	820	1.2E-04

1000-YEAR OFF-PROPERTY GROUNDWATER - ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor	10 Year Interval	Off-Property Max 10 Year Risk
35	45	830	1.5E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	830	2.3E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	830	5.8E-11	1.7E-07	3.7E-07	1.3E-06	3.5E-08	1.4E-08	1.4E-06	3.3E-06	830	1.2E-04
35	45	840	1.6E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	840	2.5E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	840	6.5E-11	1.7E-07	3.7E-07	1.3E-06	3.5E-08	1.3E-08	1.4E-06	3.3E-06	840	1.2E-04
35	45	850	1.7E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	850	2.7E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	850	7.2E-11	1.7E-07	3.7E-07	1.3E-06	3.4E-08	1.3E-08	1.4E-06	3.2E-06	850	1.2E-04
35	45	860	1.8E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	860	2.9E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	860	8.0E-11	1.7E-07	3.7E-07	1.3E-06	3.4E-08	1.3E-08	1.3E-06	3.2E-06	860	1.2E-04
35	45	870	1.9E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	870	3.1E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	870	8.8E-11	1.7E-07	3.7E-07	1.3E-06	3.4E-08	1.3E-08	1.3E-06	3.2E-06	870	1.2E-04
35	45	880	1.9E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	880	3.4E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	880	9.7E-11	1.7E-07	3.7E-07	1.3E-06	3.4E-08	1.3E-08	1.3E-06	3.2E-06	880	1.2E-04
35	45	890	2.0E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	890	3.6E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	890	1.1E-10	1.7E-07	3.7E-07	1.3E-06	3.4E-08	1.3E-08	1.3E-06	3.2E-06	890	1.2E-04
35	45	900	2.1E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	900	3.9E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	900	1.2E-10	1.7E-07	3.7E-07	1.3E-06	3.3E-08	1.3E-08	1.3E-06	3.2E-06	900	1.2E-04
35	45	910	2.2E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	910	4.1E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	910	1.3E-10	1.8E-07	3.7E-07	1.3E-06	3.3E-08	1.3E-08	1.3E-06	3.2E-06	910	1.2E-04
35	45	920	2.3E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	920	4.4E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	920	1.4E-10	1.8E-07	3.7E-07	1.2E-06	3.3E-08	1.3E-08	1.3E-06	3.2E-06	920	1.2E-04
35	45	930	2.4E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	930	4.7E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	930	1.5E-10	1.8E-07	3.7E-07	1.2E-06	3.3E-08	1.3E-08	1.3E-06	3.1E-06	930	1.2E-04
35	45	940	2.5E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	940	5.0E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	940	1.7E-10	1.8E-07	3.7E-07	1.2E-06	3.3E-08	1.3E-08	1.3E-06	3.1E-06	940	1.2E-04
35	45	950	2.6E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	950	5.3E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	950	1.8E-10	1.8E-07	3.7E-07	1.2E-06	3.3E-08	1.3E-08	1.3E-06	3.1E-06	950	1.2E-04
35	45	960	2.7E-11	1.5E-06	7.7E-05	1.8E-05	4.7E-07	1.8E-07	1.9E-05	1.2E-04		
40	40	960	5.6E-11	1.2E-06	5.9E-05	1.3E-05	3.6E-07	1.4E-07	1.4E-05	8.8E-05		
70	60	960	1.9E-10	1.8E-07	3.7E-07	1.2E-06	3.3E-08	1.3E-08	1.3E-06	3.1E-06	960	1.2E-04

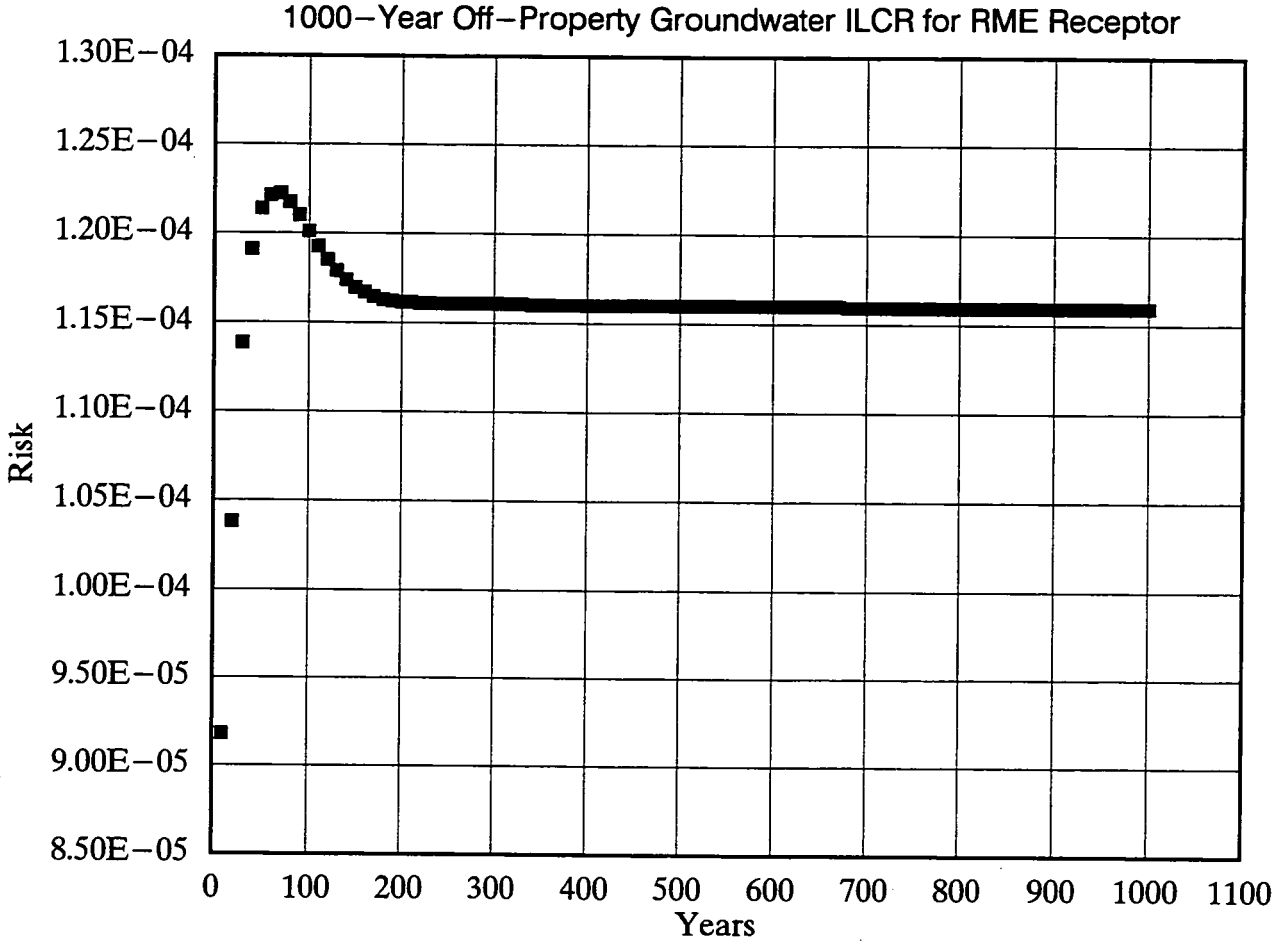
1000–YEAR OFF–PROPERTY GROUNDWATER – ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor–1221	NP–237	TC–99	U–234	U–235	U–236	U–238	Total Receptor	10 Year Interval	Off–Property Max 10 Year Risk
35	45	970	2.7E–11	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	970	5.9E–11	1.2E–06	5.9E–05	1.3E–05	3.6E–07	1.4E–07	1.4E–05	8.8E–05		
70	60	970	2.1E–10	1.8E–07	3.7E–07	1.2E–06	3.3E–08	1.3E–08	1.3E–06	3.1E–06	970	1.2E–04
35	45	980	2.8E–11	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	980	6.2E–11	1.2E–06	5.9E–05	1.3E–05	3.6E–07	1.4E–07	1.4E–05	8.8E–05		
70	60	980	2.3E–10	1.8E–07	3.7E–07	1.2E–06	3.3E–08	1.3E–08	1.3E–06	3.1E–06	980	1.2E–04
35	45	990	2.9E–11	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	990	6.5E–11	1.2E–06	5.9E–05	1.3E–05	3.6E–07	1.4E–07	1.4E–05	8.8E–05		
70	60	990	2.4E–10	1.8E–07	3.7E–07	1.2E–06	3.3E–08	1.3E–08	1.3E–06	3.1E–06	990	1.2E–04
35	45	1000	3.0E–11	1.5E–06	7.7E–05	1.8E–05	4.7E–07	1.8E–07	1.9E–05	1.2E–04		
40	40	1000	6.8E–11	1.2E–06	5.9E–05	1.3E–05	3.6E–07	1.4E–07	1.4E–05	8.8E–05		
70	60	1000	2.6E–10	1.8E–07	3.7E–07	1.2E–06	3.3E–08	1.3E–08	1.3E–06	3.1E–06	1000	1.2E–04

1000 Year Maximum Risk – 1.2E–04

10 year intervals and receptor location used are indicated by bold lettering.


1000-Year Off-Property Groundwater ILCR for RME Receptor
1.30E-04
1.25E-04
1.20E-04
1.15E-04
1.10E-04
1.05E-04
1.00E-04
9.50E-05
9.00E-05
8.50E-05
Risk
0
100
200
300
400
500
600
700
800
900
1000
1100
Years

Average Groundwater Contaminant Concentrations – Off–Property (1000 Years)

IX	IY	Time (yr)	Aroclor–122 PPB=ug/l	Antimony PPB=ug/l	Cadmium PPB=ug/l	NP–237 PPB=ug/l	TC–99 PPB=ug/l	U234 PPB=ug/l	U235 PPB=ug/l	U236 PPB=ug/l	U238 PPB=ug/l
35	45	50	6.98E–36	4.03E–07	1.43E–32	5.21E–05	7.15E–02	4.29E–03	3.28E–01	4.61E–03	4.75E+01
35	45	60	5.89E–33	2.04E–06	1.14E–29	7.75E–05	7.15E–02	4.34E–03	3.32E–01	4.66E–03	4.81E+01
35	45	70	1.54E–30	7.62E–06	2.84E–27	1.01E–04	7.16E–02	4.32E–03	3.30E–01	4.65E–03	4.79E+01
35	45	80	1.68E–28	2.29E–05	3.00E–25	1.21E–04	7.16E–02	4.26E–03	3.26E–01	4.58E–03	4.72E+01
35	45	90	9.47E–27	5.82E–05	1.64E–23	1.37E–04	7.16E–02	4.18E–03	3.19E–01	4.49E–03	4.63E+01
35	45	100	3.16E–25	1.30E–04	5.31E–22	1.50E–04	7.15E–02	4.09E–03	3.12E–01	4.39E–03	4.53E+01
35	45	110	6.89E–24	2.62E–04	1.14E–20	1.61E–04	7.15E–02	4.00E–03	3.06E–01	4.30E–03	4.43E+01
Ave Conc @ (35,45)			1.03E–24	6.90E–05	1.71E–21	1.14E–04	7.15E–02	4.21E–03	3.22E–01	4.52E–03	4.67E+01

GWCONCEN.WK3

INTAKE EQUATIONS

Chemical Intake Equation = $\frac{Cw \times EF \times ED \times FI \times IR}{BW \times AT}$

IR	Ingestion rate of groundwater (RAGS, 1989)	2	l/day
EF	Exposure frequency	350	days/year
ED	Exposure duration	70	year
FI	Fractional intake of chemicals	1	(unitless)
Cw	Concentration of chemicals in groundwater		Attachment I & II
BW	Body weight	70	kg
AT	Average time for chemicals (lifetime)	25550	days

Radionuclide Intake Equation = $Cw \times EF \times ED \times FI \times IR$

IR	Ingestion rate of groundwater (RAGS, 1989)	2	l/day
EF	Exposure frequency	350	days/year
ED	Exposure duration	70	year
FI	Fractional intake of radionuclides	1	(unitless)
Cw	Concentration of radionuclides in groundwater		Attachment I & II

CANCER SLOPE FACTORS (CSF) & RADIONUCLIDE SPECIFIC CONCENTRATIONS (CR)

Chemical	CSF	CR
Aroclor-1221	7.7E+00 1/mg/kg-day	-
Antimony	See note 1	-
Cadmium	See note 1	-
NP237	2.2E-10 risk/pCi	7.05E+02 pCi/ug
TC-99	1.3E-12 risk/pCi	1.70E+04 pCi/ug
U-234	1.6E-11 risk/pCi	6.22E+03 pCi/ug
U-235	1.6E-11 risk/pCi	2.16E+00 pCi/ug
U-236	1.5E-11 risk/pCi	6.34E+01 pCi/ug
U-238	2.8E-11 risk/pCi	3.36E-01 pCi/ug

Note 1: EPA Cancer Slope factor is not available.

1000-YEAR ON-PROPERTY GROUNDWATER - ILCR FOR RME RECEPTOR

5506

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	10	0	2.3E-06	1.7E-04	4.1E-05	1.1E-06	4.2E-07	4.3E-05	2.6E-04		
36	84	10	1.2E-14	4.2E-10	6.4E-07	8.4E-07	2.2E-08	8.6E-09	8.8E-07	2.4E-06		
40	60	10	0	1.9E-07	3.3E-05	1.2E-05	3.2E-07	1.2E-07	1.2E-05	5.8E-05		
43	91	10	5.3E-13	9.1E-09	3.7E-07	2.2E-05	5.9E-07	2.3E-07	2.3E-05	4.7E-05		
47	55	10	0	2.8E-06	3.3E-04	5.2E-05	1.4E-06	5.3E-07	5.4E-05	4.4E-04		
57	71	10	0	9.0E-25	6.0E-08	3.1E-10	8.2E-12	3.2E-12	3.2E-10	6.0E-08	10	4.4E-04
35	56	20	1.9E-41	2.9E-06	1.7E-04	4.4E-05	1.2E-06	4.5E-07	4.6E-05	2.6E-04		
36	84	20	1.3E-12	1.0E-08	6.5E-07	1.8E-06	4.6E-08	1.8E-08	1.8E-06	4.3E-06		
40	60	20	3.8E-36	3.6E-07	3.4E-05	1.3E-05	3.4E-07	1.3E-07	1.4E-05	6.1E-05		
43	91	20	1.5E-11	8.2E-08	3.7E-07	2.7E-05	7.2E-07	2.8E-07	2.8E-05	5.7E-05		
47	55	20	0	4.0E-06	3.3E-04	6.9E-05	1.8E-06	7.0E-07	7.2E-05	4.8E-04		
57	71	20	3.8E-40	1.4E-19	2.5E-07	5.1E-08	1.4E-09	5.2E-10	5.3E-08	3.6E-07	20	4.8E-04
35	56	30	3.2E-36	3.1E-06	1.7E-04	4.4E-05	1.2E-06	4.5E-07	4.6E-05	2.6E-04		
36	84	30	1.5E-11	4.3E-08	7.4E-07	2.6E-06	7.0E-08	2.7E-08	2.8E-06	6.3E-06		
40	60	30	1.3E-31	4.7E-07	3.5E-05	1.3E-05	3.4E-07	1.3E-07	1.4E-05	6.2E-05		
43	91	30	8.3E-11	2.2E-07	1.0E-06	2.9E-05	7.8E-07	3.0E-07	3.1E-05	6.2E-05		
47	55	30	2.3E-41	4.8E-06	3.3E-04	7.6E-05	2.0E-06	7.8E-07	7.9E-05	5.0E-04		
57	71	30	8.6E-35	7.3E-17	2.5E-06	3.1E-07	8.1E-09	3.1E-09	3.2E-07	3.2E-06	30	5.0E-04
35	56	40	1.4E-32	3.2E-06	1.7E-04	4.4E-05	1.2E-06	4.5E-07	4.6E-05	2.6E-04		
36	84	40	6.7E-11	9.8E-08	1.1E-06	3.1E-06	8.3E-08	3.2E-08	3.3E-06	7.7E-06		
40	60	40	1.9E-28	5.3E-07	3.5E-05	1.3E-05	3.4E-07	1.3E-07	1.3E-05	6.2E-05		
43	91	40	2.5E-10	3.7E-07	3.1E-06	3.0E-05	8.0E-07	3.1E-07	3.2E-05	6.7E-05		
47	**55**	**40**	**5.3E-37**	**5.4E-06**	**3.3E-04**	**7.8E-05**	**2.1E-06**	**8.0E-07**	**8.2E-05**	**5.0E-04**		
57	71	40	4.8E-31	3.4E-15	6.3E-06	6.5E-07	1.7E-08	6.7E-09	6.8E-07	7.7E-06	**40**	**5.0E-04**
35	56	50	7.7E-30	3.3E-06	1.7E-04	4.3E-05	1.1E-06	4.4E-07	4.5E-05	2.6E-04		
36	84	50	1.9E-10	1.6E-07	1.2E-06	3.4E-06	9.0E-08	3.5E-08	3.5E-06	8.4E-06		
40	60	50	4.6E-26	5.6E-07	3.5E-05	1.2E-05	3.2E-07	1.2E-07	1.3E-05	6.0E-05		
43	91	50	5.2E-10	5.1E-07	3.9E-06	3.1E-05	8.1E-07	3.1E-07	3.2E-05	6.8E-05		
47	**55**	**50**	**1.1E-33**	**5.8E-06**	**3.3E-04**	**8.0E-05**	**2.1E-06**	**8.2E-07**	**8.3E-05**	**5.1E-04**		
57	71	50	3.2E-28	4.6E-14	7.5E-06	9.1E-07	2.4E-08	9.4E-09	9.5E-07	9.3E-06	**50**	**5.1E-04**
35	56	60	1.2E-27	3.3E-06	1.7E-04	4.3E-05	1.1E-06	4.4E-07	4.5E-05	2.6E-04		
36	84	60	3.9E-10	2.3E-07	1.2E-06	3.5E-06	9.3E-08	3.6E-08	3.7E-06	8.7E-06		
40	60	60	3.4E-24	5.9E-07	3.5E-05	1.1E-05	3.0E-07	1.1E-07	1.2E-05	5.9E-05		
43	91	60	9.1E-10	6.4E-07	3.9E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.9E-05		
47	**55**	**60**	**4.6E-31**	**6.0E-06**	**3.3E-04**	**8.0E-05**	**2.1E-06**	**8.2E-07**	**8.4E-05**	**5.1E-04**		
57	71	60	5.4E-26	3.0E-13	7.8E-06	1.1E-06	2.9E-08	1.1E-08	1.1E-06	1.0E-05	**60**	**5.1E-04**
35	56	70	6.9E-26	3.4E-06	1.7E-04	4.2E-05	1.1E-06	4.3E-07	4.4E-05	2.6E-04		
36	84	70	6.7E-10	2.9E-07	1.2E-06	3.5E-06	9.4E-08	3.6E-08	3.7E-06	8.9E-06		
40	60	70	1.2E-22	6.0E-07	3.5E-05	1.0E-05	2.8E-07	1.1E-07	1.1E-05	5.7E-05		
43	91	70	1.4E-09	7.4E-07	3.9E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.9E-05		
47	**55**	**70**	**6.6E-29**	**6.2E-06**	**3.3E-04**	**8.0E-05**	**2.1E-06**	**8.2E-07**	**8.4E-05**	**5.1E-04**		
57	71	70	3.5E-24	1.3E-12	7.8E-06	1.3E-06	3.4E-08	1.3E-08	1.4E-06	1.1E-05	**70**	**5.1E-04**

1000-YEAR ON-PROPERTY GROUNDWATER - ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	80	2.1E-24	3.4E-06	1.7E-04	4.1E-05	1.1E-06	4.2E-07	4.3E-05	2.6E-04		
36	84	80	1.0E-09	3.4E-07	1.2E-06	3.6E-06	9.5E-08	3.7E-08	3.7E-06	8.9E-06		
40	60	80	2.2E-21	6.1E-07	3.5E-05	9.7E-06	2.6E-07	1.0E-07	1.0E-05	5.6E-05		
43	91	80	1.9E-09	8.2E-07	3.9E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.9E-05		
47	**55**	**80**	**4.3E-27**	**6.4E-06**	**3.3E-04**	**8.0E-05**	**2.1E-06**	**8.2E-07**	**8.3E-05**	**5.1E-04**		
57	71	80	1.1E-22	4.3E-12	7.8E-06	1.6E-06	4.2E-08	1.6E-08	1.6E-06	1.1E-05	**80**	**5.1E-04**
35	56	90	3.8E-23	3.4E-06	1.7E-04	4.1E-05	1.1E-06	4.2E-07	4.3E-05	2.6E-04		
36	84	90	1.4E-09	3.8E-07	1.2E-06	3.6E-06	9.5E-08	3.7E-08	3.7E-06	9.0E-06		
40	60	90	2.6E-20	6.2E-07	3.5E-05	9.2E-06	2.4E-07	9.4E-08	9.6E-06	5.5E-05		
43	91	90	2.4E-09	8.8E-07	4.0E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.9E-05		
47	**55**	**90**	**1.5E-25**	**6.5E-06**	**3.3E-04**	**7.9E-05**	**2.1E-06**	**8.1E-07**	**8.3E-05**	**5.1E-04**		
57	71	90	2.1E-21	1.3E-11	8.0E-06	1.9E-06	5.0E-08	1.9E-08	2.0E-06	1.2E-05	**90**	**5.1E-04**
35	56	100	4.6E-22	3.4E-06	1.7E-04	4.0E-05	1.1E-06	4.1E-07	4.2E-05	2.6E-04		
36	84	100	1.9E-09	4.1E-07	9.8E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.9E-06		
40	60	100	2.2E-19	6.3E-07	3.4E-05	8.8E-06	2.3E-07	9.1E-08	9.3E-06	5.3E-05		
43	91	100	3.0E-09	9.3E-07	2.9E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.8E-05		
47	**55**	**100**	**3.2E-24**	**6.6E-06**	**3.3E-04**	**7.9E-05**	**2.1E-06**	**8.1E-07**	**8.3E-05**	**5.0E-04**		
57	71	100	2.7E-20	3.5E-11	5.5E-06	2.2E-06	6.0E-08	2.3E-08	2.4E-06	1.0E-05	**100**	**5.0E-04**
35	56	110	4.1E-21	3.4E-06	1.7E-04	4.0E-05	1.1E-06	4.1E-07	4.2E-05	2.6E-04		
36	84	110	2.3E-09	4.4E-07	6.4E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	110	1.4E-18	6.3E-07	3.4E-05	8.6E-06	2.3E-07	8.8E-08	9.0E-06	5.3E-05		
43	91	110	3.6E-09	9.7E-07	8.0E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	110	4.7E-23	6.6E-06	3.3E-04	7.8E-05	2.1E-06	8.0E-07	8.2E-05	5.0E-04		
57	71	110	2.4E-19	9.3E-11	1.9E-06	2.6E-06	6.8E-08	2.6E-08	2.7E-06	7.2E-06	110	5.0E-04
35	56	120	2.8E-20	3.4E-06	1.7E-04	4.0E-05	1.1E-06	4.1E-07	4.2E-05	2.6E-04		
36	84	120	2.7E-09	4.6E-07	5.6E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.5E-06		
40	60	120	7.4E-18	6.3E-07	3.4E-05	8.4E-06	2.2E-07	8.6E-08	8.8E-06	5.2E-05		
43	91	120	4.1E-09	9.9E-07	7.5E-08	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	120	5.1E-22	6.6E-06	3.3E-04	7.8E-05	2.1E-06	8.0E-07	8.2E-05	5.0E-04		
57	71	120	1.7E-18	2.3E-10	5.7E-07	2.9E-06	7.6E-08	2.9E-08	3.0E-06	6.5E-06	120	5.0E-04
35	56	130	1.5E-19	3.4E-06	1.7E-04	4.0E-05	1.1E-06	4.1E-07	4.1E-05	2.6E-04		
36	84	130	3.2E-09	4.8E-07	5.6E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.5E-06		
40	60	130	3.1E-17	6.4E-07	3.4E-05	8.2E-06	2.2E-07	8.5E-08	8.6E-06	5.2E-05		
43	91	130	4.6E-09	1.0E-06	9.2E-09	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	130	4.2E-21	6.7E-06	3.3E-04	7.8E-05	2.1E-06	8.0E-07	8.2E-05	5.0E-04		
57	71	130	9.1E-18	5.1E-10	2.4E-07	3.1E-06	8.2E-08	3.2E-08	3.2E-06	6.7E-06	130	5.0E-04
35	56	140	7.0E-19	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	140	3.6E-09	4.9E-07	5.6E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.5E-06		
40	60	140	1.1E-16	6.4E-07	3.4E-05	8.1E-06	2.2E-07	8.4E-08	8.5E-06	5.2E-05		
43	91	140	5.1E-09	1.0E-06	2.1E-08	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	140	2.7E-20	6.7E-06	3.3E-04	7.7E-05	2.1E-06	8.0E-07	8.1E-05	5.0E-04		
57	71	140	4.1E-17	1.0E-09	2.0E-07	3.3E-06	8.7E-08	3.4E-08	3.4E-06	7.0E-06	140	5.0E-04
35	56	150	2.7E-18	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	150	4.0E-09	5.0E-07	5.6E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.5E-06		
40	60	150	3.6E-16	6.4E-07	3.4E-05	8.1E-06	2.1E-07	8.3E-08	8.5E-06	5.2E-05		
43	91	150	5.5E-09	1.0E-06	4.8E-08	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	150	1.5E-19	6.7E-06	3.3E-04	7.7E-05	2.1E-06	8.0E-07	8.1E-05	5.0E-04		
57	71	150	1.6E-16	2.0E-09	1.9E-07	3.4E-06	9.0E-08	3.5E-08	3.6E-06	7.3E-06	150	5.0E-04

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	160	9.2E-18	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	160	4.3E-09	5.1E-07	5.6E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	160	1.0E-15	6.4E-07	3.4E-05	8.1E-06	2.1E-07	8.3E-08	8.4E-06	5.1E-05		
43	91	160	5.9E-09	1.0E-06	9.5E-08	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	160	6.9E-19	6.7E-06	3.3E-04	7.7E-05	2.1E-06	8.0E-07	8.1E-05	5.0E-04		
57	71	160	5.3E-16	3.5E-09	2.0E-07	3.5E-06	9.3E-08	3.6E-08	3.7E-06	7.5E-06	160	5.0E-04
35	56	170	2.8E-17	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	170	4.7E-09	5.2E-07	5.6E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	170	2.6E-15	6.4E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.4E-06	5.1E-05		
43	91	170	6.3E-09	1.1E-06	1.7E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	170	2.7E-18	6.7E-06	3.3E-04	7.7E-05	2.1E-06	8.0E-07	8.1E-05	5.0E-04		
57	71	170	1.6E-15	5.7E-09	2.0E-07	3.6E-06	9.5E-08	3.7E-08	3.7E-06	7.7E-06	170	5.0E-04
35	56	180	7.7E-17	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	180	5.0E-09	5.2E-07	5.6E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	180	6.0E-15	6.4E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.4E-06	5.1E-05		
43	91	180	6.6E-09	1.1E-06	2.7E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	180	9.7E-18	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	180	4.3E-15	8.9E-09	2.1E-07	3.6E-06	9.6E-08	3.7E-08	3.8E-06	7.8E-06	180	5.0E-04
35	56	190	1.9E-16	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	190	5.3E-09	5.3E-07	5.7E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	190	1.3E-14	6.5E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.4E-06	5.1E-05		
43	91	190	6.9E-09	1.1E-06	4.0E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	190	3.1E-17	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	190	1.1E-14	1.3E-08	2.3E-07	3.7E-06	9.7E-08	3.8E-08	3.8E-06	7.9E-06	190	5.0E-04
35	56	200	4.4E-16	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	200	5.5E-09	5.3E-07	5.7E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	200	2.6E-14	6.5E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	200	7.2E-09	1.1E-06	5.5E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	200	9.0E-17	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	200	2.4E-14	1.8E-08	2.5E-07	3.7E-06	9.8E-08	3.8E-08	3.9E-06	8.0E-06	200	5.0E-04
35	56	210	9.6E-16	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	210	5.8E-09	5.3E-07	5.7E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	210	5.0E-14	6.5E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	210	7.4E-09	1.1E-06	7.2E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	210	2.4E-16	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	210	5.2E-14	2.5E-08	2.7E-07	3.7E-06	9.8E-08	3.8E-08	3.9E-06	8.0E-06	210	5.0E-04
35	56	220	1.9E-15	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	220	6.0E-09	5.3E-07	5.8E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	220	9.1E-14	6.5E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	220	7.6E-09	1.1E-06	8.8E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	220	5.8E-16	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	220	1.0E-13	3.3E-08	2.9E-07	3.7E-06	9.9E-08	3.8E-08	3.9E-06	8.1E-06	220	5.0E-04
35	56	230	3.7E-15	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	230	6.1E-09	5.3E-07	5.8E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	230	1.6E-13	6.5E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	230	7.8E-09	1.1E-06	1.0E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	230	1.3E-15	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	230	2.0E-13	4.2E-08	3.2E-07	3.7E-06	9.9E-08	3.8E-08	3.9E-06	8.1E-06	230	5.0E-04

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	240	6.8E-15	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	240	6.3E-09	5.4E-07	5.8E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	240	2.6E-13	6.5E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	240	8.0E-09	1.1E-06	1.1E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	240	2.9E-15	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	240	3.5E-13	5.2E-08	3.4E-07	3.7E-06	9.9E-08	3.8E-08	3.9E-06	8.2E-06	240	5.0E-04
35	56	250	1.2E-14	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	250	6.5E-09	5.4E-07	5.9E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	250	4.1E-13	6.6E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	250	8.1E-09	1.1E-06	1.2E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	250	5.9E-15	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	250	6.1E-13	6.2E-08	3.6E-07	3.7E-06	1.0E-07	3.9E-08	3.9E-06	8.2E-06	250	5.0E-04
35	56	260	2.0E-14	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	260	6.6E-09	5.4E-07	5.9E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	260	6.3E-13	6.6E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	260	8.3E-09	1.1E-06	1.3E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	260	1.2E-14	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	260	1.0E-12	7.4E-08	3.7E-07	3.8E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	260	5.0E-04
35	56	270	3.2E-14	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	270	6.7E-09	5.4E-07	5.9E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	270	9.4E-13	6.6E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	270	8.4E-09	1.1E-06	1.3E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	270	2.2E-14	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	270	1.6E-12	8.6E-08	3.8E-07	3.8E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	270	5.0E-04
35	56	280	5.0E-14	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	280	6.8E-09	5.4E-07	5.9E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	280	1.4E-12	6.6E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	280	8.5E-09	1.1E-06	1.2E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	280	3.9E-14	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	280	2.5E-12	9.8E-08	3.8E-07	3.8E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	280	5.0E-04
35	56	290	7.6E-14	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	290	6.9E-09	5.4E-07	5.9E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	290	1.9E-12	6.6E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	290	8.6E-09	1.1E-06	1.1E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	290	6.6E-14	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	290	3.8E-12	1.1E-07	3.7E-07	3.8E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	290	5.0E-04
35	56	300	1.1E-13	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	300	7.0E-09	5.4E-07	5.9E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	300	2.6E-12	6.6E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	300	8.7E-09	1.1E-06	1.0E-06	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	300	1.1E-13	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	300	5.5E-12	1.2E-07	3.6E-07	3.8E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	300	5.0E-04
35	56	310	1.6E-13	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	310	7.1E-09	5.4E-07	5.9E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	310	3.6E-12	6.7E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	310	8.8E-09	1.1E-06	9.2E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	310	1.8E-13	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	310	7.9E-12	1.4E-07	3.5E-07	3.8E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	310	5.0E-04

1000-YEAR ON-PROPERTY GROUNDWATER - ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

550A

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	320	2.2E-13	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	320	7.2E-09	5.4E-07	5.8E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	320	4.7E-12	6.7E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	320	8.8E-09	1.1E-06	8.0E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.7E-05		
47	55	320	2.8E-13	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	320	1.1E-11	1.5E-07	3.3E-07	3.8E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	320	5.0E-04
35	56	330	3.1E-13	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	330	7.2E-09	5.4E-07	5.8E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	330	6.1E-12	6.7E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	330	8.9E-09	1.1E-06	6.8E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	330	4.2E-13	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	330	1.5E-11	1.6E-07	3.1E-07	3.8E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	330	5.0E-04
35	56	340	4.1E-13	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	340	7.3E-09	5.4E-07	5.8E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	340	7.8E-12	6.7E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	340	8.9E-09	1.1E-06	5.7E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	340	6.2E-13	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	340	2.0E-11	1.7E-07	3.0E-07	3.8E-06	1.0E-07	3.9E-08	4.0E-06	8.3E-06	340	5.0E-04
35	56	350	5.5E-13	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	350	7.3E-09	5.4E-07	5.8E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	350	9.9E-12	6.7E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	350	9.0E-09	1.1E-06	4.7E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	350	9.1E-13	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	350	2.7E-11	1.8E-07	2.8E-07	3.8E-06	1.0E-07	3.9E-08	4.0E-06	8.3E-06	350	5.0E-04
35	56	360	7.1E-13	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	360	7.4E-09	5.4E-07	5.7E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	360	1.2E-11	6.7E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	360	9.1E-09	1.1E-06	3.8E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	360	1.3E-12	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	360	3.4E-11	1.9E-07	2.7E-07	3.8E-06	1.0E-07	3.9E-08	4.0E-06	8.3E-06	360	5.0E-04
35	56	370	9.1E-13	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	370	7.4E-09	5.4E-07	5.7E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	8.6E-06		
40	60	370	1.5E-11	6.7E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	370	9.1E-09	1.1E-06	3.0E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	370	1.8E-12	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	370	4.4E-11	2.0E-07	2.5E-07	3.8E-06	1.0E-07	3.9E-08	4.0E-06	8.3E-06	370	5.0E-04
35	56	380	1.2E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	380	7.4E-09	5.4E-07	5.7E-07	3.5E-06	9.3E-08	3.6E-08	3.7E-06	8.4E-06		
40	60	380	1.8E-11	6.7E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	380	9.1E-09	1.1E-06	2.4E-07	3.1E-05	8.2E-07	3.2E-07	3.2E-05	6.6E-05		
47	55	380	2.4E-12	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	380	5.5E-11	2.1E-07	2.4E-07	3.8E-06	1.0E-07	3.9E-08	4.0E-06	8.3E-06	380	5.0E-04
35	56	390	1.4E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	390	7.5E-09	5.4E-07	5.7E-07	3.1E-06	8.3E-08	3.2E-08	3.3E-06	7.6E-06		
40	60	390	2.2E-11	6.7E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	390	9.2E-09	1.1E-06	1.9E-07	3.0E-05	8.0E-07	3.1E-07	3.2E-05	6.4E-05		
47	55	390	3.3E-12	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	390	6.9E-11	2.2E-07	2.3E-07	3.8E-06	1.0E-07	3.9E-08	4.0E-06	8.3E-06	390	5.0E-04

000742

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	400	1.8E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	400	7.5E-09	5.4E-07	5.7E-07	2.8E-06	7.5E-08	2.9E-08	3.0E-06	7.0E-06		
40	60	400	2.6E-11	6.8E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	400	9.2E-09	1.1E-06	1.5E-07	3.0E-05	8.0E-07	3.1E-07	3.1E-05	6.4E-05		
47	55	400	4.4E-12	6.8E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	400	8.4E-11	2.2E-07	2.2E-07	3.8E-06	1.0E-07	3.9E-08	4.0E-06	8.3E-06	400	5.0E-04
35	56	410	2.2E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	410	7.5E-09	5.4E-07	5.6E-07	2.7E-06	7.2E-08	2.8E-08	2.8E-06	6.8E-06		
40	60	410	3.0E-11	6.8E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	410	9.2E-09	1.1E-06	1.1E-07	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	410	5.7E-12	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	410	1.0E-10	2.3E-07	2.2E-07	3.8E-06	1.0E-07	3.9E-08	4.0E-06	8.3E-06	410	5.0E-04
35	56	420	2.6E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	420	7.6E-09	5.4E-07	5.6E-07	2.7E-06	7.1E-08	2.7E-08	2.8E-06	6.7E-06		
40	60	420	3.5E-11	6.8E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	420	9.2E-09	1.1E-06	8.4E-08	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	420	7.3E-12	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	420	1.2E-10	2.4E-07	2.1E-07	3.8E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	420	5.0E-04
35	56	430	3.1E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	430	7.6E-09	5.4E-07	5.6E-07	2.6E-06	7.0E-08	2.7E-08	2.8E-06	6.6E-06		
40	60	430	4.1E-11	6.8E-07	3.4E-05	8.0E-06	2.1E-07	8.2E-08	8.3E-06	5.1E-05		
43	91	430	9.2E-09	1.1E-06	6.4E-08	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	430	9.3E-12	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	430	1.5E-10	2.4E-07	2.1E-07	3.7E-06	1.0E-07	3.9E-08	3.9E-06	8.3E-06	430	5.0E-04
35	56	440	3.6E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	440	7.6E-09	5.4E-07	5.6E-07	2.6E-06	7.0E-08	2.7E-08	2.8E-06	6.6E-06		
40	60	440	4.7E-11	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	440	9.3E-09	1.1E-06	4.8E-08	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	440	1.2E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	440	1.7E-10	2.5E-07	2.0E-07	3.7E-06	9.8E-08	3.8E-08	3.9E-06	8.2E-06	440	5.0E-04
35	56	450	4.2E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	450	7.6E-09	5.4E-07	5.6E-07	2.6E-06	7.0E-08	2.7E-08	2.8E-06	6.6E-06		
40	60	450	5.3E-11	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	450	9.3E-09	1.1E-06	3.6E-08	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	450	1.4E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	450	2.0E-10	2.5E-07	2.0E-07	3.7E-06	9.7E-08	3.8E-08	3.8E-06	8.1E-06	450	5.0E-04
35	56	460	4.9E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	460	7.6E-09	5.4E-07	5.6E-07	2.6E-06	7.0E-08	2.7E-08	2.8E-06	6.6E-06		
40	60	460	6.0E-11	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	460	9.3E-09	1.1E-06	2.7E-08	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	460	1.8E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	460	2.3E-10	2.6E-07	2.0E-07	3.6E-06	9.5E-08	3.7E-08	3.8E-06	7.9E-06	460	5.0E-04
35	56	470	5.7E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	470	7.6E-09	5.4E-07	5.6E-07	2.6E-06	7.0E-08	2.7E-08	2.8E-06	6.6E-06		
40	60	470	6.7E-11	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	470	9.3E-09	1.1E-06	2.1E-08	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	470	2.2E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	470	2.7E-10	2.6E-07	2.0E-07	3.5E-06	9.3E-08	3.6E-08	3.7E-06	7.8E-06	470	5.0E-04

5506

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	480	6.5E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	480	7.7E-09	5.4E-07	5.6E-07	2.7E-06	7.0E-08	2.7E-08	2.8E-06	6.6E-06		
40	60	480	7.5E-11	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	480	9.3E-09	1.1E-06	1.6E-08	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	480	2.6E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	480	3.0E-10	2.6E-07	1.9E-07	3.5E-06	9.2E-08	3.5E-08	3.6E-06	7.7E-06	480	5.0E-04
35	56	490	7.4E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	490	7.7E-09	5.4E-07	5.6E-07	2.7E-06	7.1E-08	2.7E-08	2.8E-06	6.7E-06		
40	60	490	8.3E-11	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	490	9.3E-09	1.1E-06	1.2E-08	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	490	3.1E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	490	3.5E-10	2.7E-07	1.9E-07	3.4E-06	9.0E-08	3.5E-08	3.6E-06	7.6E-06	490	5.0E-04
35	56	500	8.3E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	500	7.7E-09	5.4E-07	5.6E-07	2.7E-06	7.1E-08	2.7E-08	2.8E-06	6.7E-06		
40	60	500	9.2E-11	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	500	9.3E-09	1.1E-06	9.4E-09	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	500	3.7E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	500	3.9E-10	2.7E-07	1.9E-07	3.4E-06	8.9E-08	3.4E-08	3.5E-06	7.5E-06	500	5.0E-04
35	56	510	9.3E-12	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	510	7.7E-09	5.4E-07	5.6E-07	2.7E-06	7.1E-08	2.8E-08	2.8E-06	6.7E-06		
40	60	510	1.0E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	510	9.3E-09	1.1E-06	7.4E-09	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	510	4.3E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	510	4.3E-10	2.7E-07	1.9E-07	3.3E-06	8.8E-08	3.4E-08	3.5E-06	7.4E-06	510	5.0E-04
35	56	520	1.0E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	520	7.7E-09	5.4E-07	5.6E-07	2.7E-06	7.1E-08	2.8E-08	2.8E-06	6.7E-06		
40	60	520	1.1E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	520	9.4E-09	1.1E-06	6.1E-09	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	520	5.0E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	520	4.9E-10	2.8E-07	1.9E-07	3.3E-06	8.8E-08	3.4E-08	3.5E-06	7.3E-06	520	5.0E-04
35	56	530	1.2E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	530	7.7E-09	5.4E-07	5.6E-07	2.7E-06	7.2E-08	2.8E-08	2.8E-06	6.7E-06		
40	60	530	1.2E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	530	9.4E-09	1.1E-06	5.1E-09	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	530	5.8E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	530	5.4E-10	2.8E-07	1.9E-07	3.3E-06	8.7E-08	3.4E-08	3.4E-06	7.3E-06	530	5.0E-04
35	56	540	1.3E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	540	7.7E-09	5.4E-07	5.6E-07	2.7E-06	7.2E-08	2.8E-08	2.8E-06	6.8E-06		
40	60	540	1.3E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	540	9.4E-09	1.1E-06	4.4E-09	3.0E-05	7.9E-07	3.1E-07	3.1E-05	6.3E-05		
47	55	540	6.7E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	540	5.9E-10	2.8E-07	1.9E-07	3.3E-06	8.7E-08	3.4E-08	3.4E-06	7.3E-06	540	5.0E-04
35	56	550	1.4E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	550	7.7E-09	5.4E-07	5.6E-07	2.6E-06	6.8E-08	2.6E-08	2.7E-06	6.4E-06		
40	60	550	1.4E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	550	9.4E-09	1.1E-06	3.9E-09	2.9E-05	7.7E-07	3.0E-07	3.0E-05	6.1E-05		
47	55	550	7.7E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	550	6.5E-10	2.8E-07	1.9E-07	3.3E-06	8.7E-08	3.3E-08	3.4E-06	7.3E-06	550	5.0E-04

1000-YEAR ON-PROPERTY GROUNDWATER - ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	560	1.5E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	560	7.7E-09	5.4E-07	5.6E-07	1.8E-06	4.7E-08	1.8E-08	1.9E-06	4.8E-06		
40	60	560	1.5E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	560	9.4E-09	1.1E-06	3.5E-09	2.7E-05	7.1E-07	2.8E-07	2.8E-05	5.7E-05		
47	55	560	8.7E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	560	7.1E-10	2.8E-07	1.9E-07	3.3E-06	8.6E-08	3.3E-08	3.4E-06	7.3E-06	560	5.0E-04
35	56	570	1.7E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	570	7.7E-09	5.4E-07	5.6E-07	1.1E-06	2.9E-08	1.1E-08	1.1E-06	3.4E-06		
40	60	570	1.6E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	570	9.4E-09	1.1E-06	3.2E-09	2.6E-05	6.8E-07	2.6E-07	2.7E-05	5.5E-05		
47	55	570	9.8E-11	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	570	7.7E-10	2.8E-07	1.9E-07	3.3E-06	8.6E-08	3.3E-08	3.4E-06	7.3E-06	570	5.0E-04
35	56	580	1.8E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	580	7.7E-09	5.4E-07	5.6E-07	7.0E-07	1.9E-08	7.2E-09	7.3E-07	2.6E-06		
40	60	580	1.7E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	580	9.4E-09	1.1E-06	3.1E-09	2.5E-05	6.7E-07	2.6E-07	2.6E-05	5.4E-05		
47	55	580	1.1E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	580	8.4E-10	2.8E-07	1.9E-07	3.2E-06	8.6E-08	3.3E-08	3.4E-06	7.2E-06	580	5.0E-04
35	56	590	1.9E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	590	7.7E-09	5.4E-07	5.6E-07	5.1E-07	1.4E-08	5.3E-09	5.4E-07	2.2E-06		
40	60	590	1.8E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	590	9.4E-09	1.1E-06	2.9E-09	2.5E-05	6.6E-07	2.6E-07	2.6E-05	5.3E-05		
47	55	590	1.2E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	590	9.0E-10	2.9E-07	1.9E-07	3.2E-06	8.6E-08	3.3E-08	3.4E-06	7.2E-06	590	5.0E-04
35	56	600	2.1E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	600	7.7E-09	5.4E-07	5.6E-07	4.3E-07	1.1E-08	4.4E-09	4.5E-07	2.0E-06		
40	60	600	1.9E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	600	9.4E-09	1.1E-06	2.8E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	600	1.4E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	600	9.7E-10	2.9E-07	1.9E-07	3.2E-06	8.5E-08	3.3E-08	3.4E-06	7.2E-06	600	5.0E-04
35	56	610	2.2E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	610	7.7E-09	5.4E-07	5.6E-07	4.0E-07	1.1E-08	4.1E-09	4.2E-07	1.9E-06		
40	60	610	2.0E-10	6.8E-07	3.4E-05	7.9E-06	2.1E-07	8.1E-08	8.3E-06	5.1E-05		
43	91	610	9.4E-09	1.1E-06	2.8E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	610	1.5E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	610	1.0E-09	2.9E-07	1.9E-07	3.1E-06	8.3E-08	3.2E-08	3.3E-06	7.0E-06	610	5.0E-04
35	56	620	2.4E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	620	7.7E-09	5.4E-07	5.6E-07	3.9E-07	1.0E-08	4.0E-09	4.1E-07	1.9E-06		
40	60	620	2.1E-10	6.8E-07	3.4E-05	7.8E-06	2.1E-07	8.0E-08	8.2E-06	5.1E-05		
43	91	620	9.4E-09	1.1E-06	2.7E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	620	1.7E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	620	1.1E-09	2.9E-07	1.9E-07	3.0E-06	8.0E-08	3.1E-08	3.2E-06	6.8E-06	620	5.0E-04
35	56	630	2.6E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	630	7.7E-09	5.4E-07	5.6E-07	3.9E-07	1.0E-08	4.0E-09	4.1E-07	1.9E-06		
40	60	630	2.2E-10	6.8E-07	3.4E-05	7.8E-06	2.1E-07	8.0E-08	8.2E-06	5.1E-05		
43	91	630	9.4E-09	1.1E-06	2.7E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	630	1.8E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	630	1.2E-09	2.9E-07	1.9E-07	2.9E-06	7.6E-08	2.9E-08	3.0E-06	6.5E-06	630	5.0E-04

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	640	2.7E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	640	7.7E-09	5.4E-07	5.6E-07	3.9E-07	1.0E-08	4.0E-09	4.1E-07	1.9E-06		
40	60	640	2.3E-10	6.8E-07	3.4E-05	7.8E-06	2.1E-07	8.0E-08	8.2E-06	5.1E-05		
43	91	640	9.4E-09	1.1E-06	2.7E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	640	2.0E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.1E-05	5.0E-04		
57	71	640	1.3E-09	2.9E-07	1.9E-07	2.7E-06	7.1E-08	2.8E-08	2.8E-06	6.1E-06	640	5.0E-04
35	56	650	2.9E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	650	7.7E-09	5.4E-07	5.6E-07	4.0E-07	1.1E-08	4.1E-09	4.2E-07	1.9E-06		
40	60	650	2.4E-10	6.8E-07	3.4E-05	7.8E-06	2.1E-07	8.0E-08	8.2E-06	5.1E-05		
43	91	650	9.4E-09	1.1E-06	2.7E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	650	2.2E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	650	1.3E-09	2.9E-07	1.9E-07	2.5E-06	6.7E-08	2.6E-08	2.7E-06	5.8E-06	650	5.0E-04
35	56	660	3.0E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	660	7.8E-09	5.4E-07	5.6E-07	4.1E-07	1.1E-08	4.2E-09	4.3E-07	2.0E-06		
40	60	660	2.6E-10	6.8E-07	3.4E-05	7.7E-06	2.1E-07	8.0E-08	8.1E-06	5.1E-05		
43	91	660	9.4E-09	1.1E-06	2.7E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	660	2.4E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	660	1.4E-09	2.9E-07	1.9E-07	2.4E-06	6.3E-08	2.4E-08	2.5E-06	5.4E-06	660	5.0E-04
35	56	670	3.2E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	670	7.8E-09	5.4E-07	5.6E-07	4.2E-07	1.1E-08	4.3E-09	4.4E-07	2.0E-06		
40	60	670	2.7E-10	6.8E-07	3.4E-05	7.7E-06	2.1E-07	8.0E-08	8.1E-06	5.1E-05		
43	91	670	9.4E-09	1.1E-06	2.7E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	670	2.6E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	670	1.5E-09	2.9E-07	1.9E-07	2.3E-06	6.0E-08	2.3E-08	2.4E-06	5.2E-06	670	5.0E-04
35	56	680	3.4E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	680	7.8E-09	5.4E-07	5.6E-07	4.3E-07	1.1E-08	4.4E-09	4.5E-07	2.0E-06		
40	60	680	2.8E-10	6.8E-07	3.4E-05	7.7E-06	2.1E-07	8.0E-08	8.1E-06	5.1E-05		
43	91	680	9.4E-09	1.1E-06	2.7E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	680	2.8E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	680	1.5E-09	2.9E-07	1.9E-07	2.2E-06	5.7E-08	2.2E-08	2.3E-06	5.0E-06	680	5.0E-04
35	56	690	3.5E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	690	7.8E-09	5.4E-07	5.6E-07	4.4E-07	1.2E-08	4.5E-09	4.6E-07	2.0E-06		
40	60	690	2.9E-10	6.8E-07	3.4E-05	7.7E-06	2.1E-07	8.0E-08	8.1E-06	5.1E-05		
43	91	690	9.4E-09	1.1E-06	2.7E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	690	3.0E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	690	1.6E-09	2.9E-07	1.9E-07	2.1E-06	5.5E-08	2.1E-08	2.2E-06	4.8E-06	690	5.0E-04
35	56	700	3.7E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	700	7.8E-09	5.4E-07	5.6E-07	4.5E-07	1.2E-08	4.6E-09	4.7E-07	2.0E-06		
40	60	700	3.0E-10	6.8E-07	3.4E-05	7.7E-06	2.1E-07	8.0E-08	8.1E-06	5.1E-05		
43	91	700	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	700	3.2E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	700	1.7E-09	2.9E-07	1.9E-07	2.0E-06	5.4E-08	2.1E-08	2.1E-06	4.7E-06	700	5.0E-04
35	56	710	3.8E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	710	7.8E-09	5.4E-07	5.6E-07	4.5E-07	1.2E-08	4.7E-09	4.7E-07	2.1E-06		
40	60	710	3.1E-10	6.8E-07	3.4E-05	7.7E-06	2.1E-07	8.0E-08	8.1E-06	5.1E-05		
43	91	710	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	710	3.4E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	710	1.8E-09	2.9E-07	1.9E-07	2.0E-06	5.3E-08	2.0E-08	2.1E-06	4.6E-06	710	5.0E-04

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	720	4.0E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	720	7.8E-09	5.4E-07	5.6E-07	4.6E-07	1.2E-08	4.7E-09	4.8E-07	2.1E-06		
40	60	720	3.2E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	720	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	720	3.6E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	720	1.8E-09	2.9E-07	1.9E-07	2.0E-06	5.2E-08	2.0E-08	2.1E-06	4.6E-06	720	5.0E-04
35	56	730	4.2E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	730	7.8E-09	5.4E-07	5.6E-07	4.6E-07	1.2E-08	4.7E-09	4.8E-07	2.1E-06		
40	60	730	3.3E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	730	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	730	3.8E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	730	1.9E-09	2.9E-07	1.9E-07	1.9E-06	5.2E-08	2.0E-08	2.0E-06	4.5E-06	730	5.0E-04
35	56	740	4.3E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	740	7.8E-09	5.4E-07	5.6E-07	4.6E-07	1.2E-08	4.7E-09	4.8E-07	2.1E-06		
40	60	740	3.4E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	740	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	740	4.1E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	740	2.0E-09	2.9E-07	1.9E-07	1.9E-06	5.1E-08	2.0E-08	2.0E-06	4.5E-06	740	5.0E-04
35	56	750	4.5E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	750	7.8E-09	5.4E-07	5.6E-07	4.6E-07	1.2E-08	4.7E-09	4.8E-07	2.1E-06		
40	60	750	3.5E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	750	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	750	4.3E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	750	2.1E-09	2.9E-07	1.9E-07	1.9E-06	5.1E-08	2.0E-08	2.0E-06	4.5E-06	750	5.0E-04
35	56	760	4.6E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	760	7.8E-09	5.4E-07	5.6E-07	4.6E-07	1.2E-08	4.7E-09	4.8E-07	2.1E-06		
40	60	760	3.5E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	760	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	760	4.5E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	760	2.1E-09	2.9E-07	1.9E-07	1.9E-06	5.1E-08	2.0E-08	2.0E-06	4.5E-06	760	5.0E-04
35	56	770	4.8E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	770	7.8E-09	5.4E-07	5.6E-07	4.5E-07	1.2E-08	4.7E-09	4.7E-07	2.1E-06		
40	60	770	3.6E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	770	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	770	4.8E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	770	2.2E-09	2.9E-07	1.9E-07	1.9E-06	5.1E-08	2.0E-08	2.0E-06	4.5E-06	770	5.0E-04
35	56	780	4.9E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	780	7.8E-09	5.4E-07	5.6E-07	4.5E-07	1.2E-08	4.6E-09	4.7E-07	2.0E-06		
40	60	780	3.7E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	780	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	780	5.0E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	780	2.3E-09	2.9E-07	1.9E-07	1.9E-06	5.0E-08	2.0E-08	2.0E-06	4.4E-06	780	5.0E-04
35	56	790	5.1E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	790	7.8E-09	5.4E-07	5.6E-07	4.4E-07	1.2E-08	4.5E-09	4.6E-07	2.0E-06		
40	60	790	3.8E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	790	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	790	5.3E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	790	2.3E-09	2.9E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	790	5.0E-04

1000-YEAR ON-PROPERTY GROUNDWATER - ILCR FOR RME RECEPTOR

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	800	5.2E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	800	7.8E-09	5.4E-07	5.6E-07	4.3E-07	1.1E-08	4.4E-09	4.5E-07	2.0E-06		
40	60	800	3.9E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	800	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	800	5.5E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	800	2.4E-09	2.9E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	800	5.0E-04
35	56	810	5.3E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	810	7.8E-09	5.4E-07	5.6E-07	4.2E-07	1.1E-08	4.3E-09	4.4E-07	2.0E-06		
40	60	810	4.0E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	810	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	810	5.7E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	810	2.4E-09	2.9E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	810	5.0E-04
35	56	820	5.5E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	820	7.8E-09	5.4E-07	5.6E-07	4.1E-07	1.1E-08	4.2E-09	4.3E-07	2.0E-06		
40	60	820	4.0E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	820	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	820	6.0E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	820	2.5E-09	2.9E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	820	5.0E-04
35	56	830	5.6E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	830	7.8E-09	5.4E-07	5.6E-07	4.0E-07	1.1E-08	4.1E-09	4.2E-07	1.9E-06		
40	60	830	4.1E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	830	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	830	6.2E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	830	2.6E-09	2.9E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	830	5.0E-04
35	56	840	5.7E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	840	7.8E-09	5.4E-07	5.6E-07	3.9E-07	1.0E-08	4.0E-09	4.0E-07	1.9E-06		
40	60	840	4.2E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	840	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	840	6.5E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	840	2.6E-09	2.9E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	840	5.0E-04
35	56	850	5.9E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	850	7.8E-09	5.4E-07	5.6E-07	3.7E-07	9.9E-09	3.8E-09	3.9E-07	1.9E-06		
40	60	850	4.2E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	850	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	850	6.7E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	850	2.7E-09	2.9E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	850	5.0E-04
35	56	860	6.0E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	860	7.8E-09	5.4E-07	5.6E-07	3.6E-07	9.6E-09	3.7E-09	3.8E-07	1.9E-06		
40	60	860	4.3E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	860	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	860	6.9E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	860	2.7E-09	2.9E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	860	5.0E-04
35	56	870	6.1E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	870	7.8E-09	5.4E-07	5.6E-07	3.5E-07	9.2E-09	3.6E-09	3.6E-07	1.8E-06		
40	60	870	4.4E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	870	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	870	7.2E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	870	2.8E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	870	5.0E-04

INCREMENTAL LIFETIME CANCER RISK

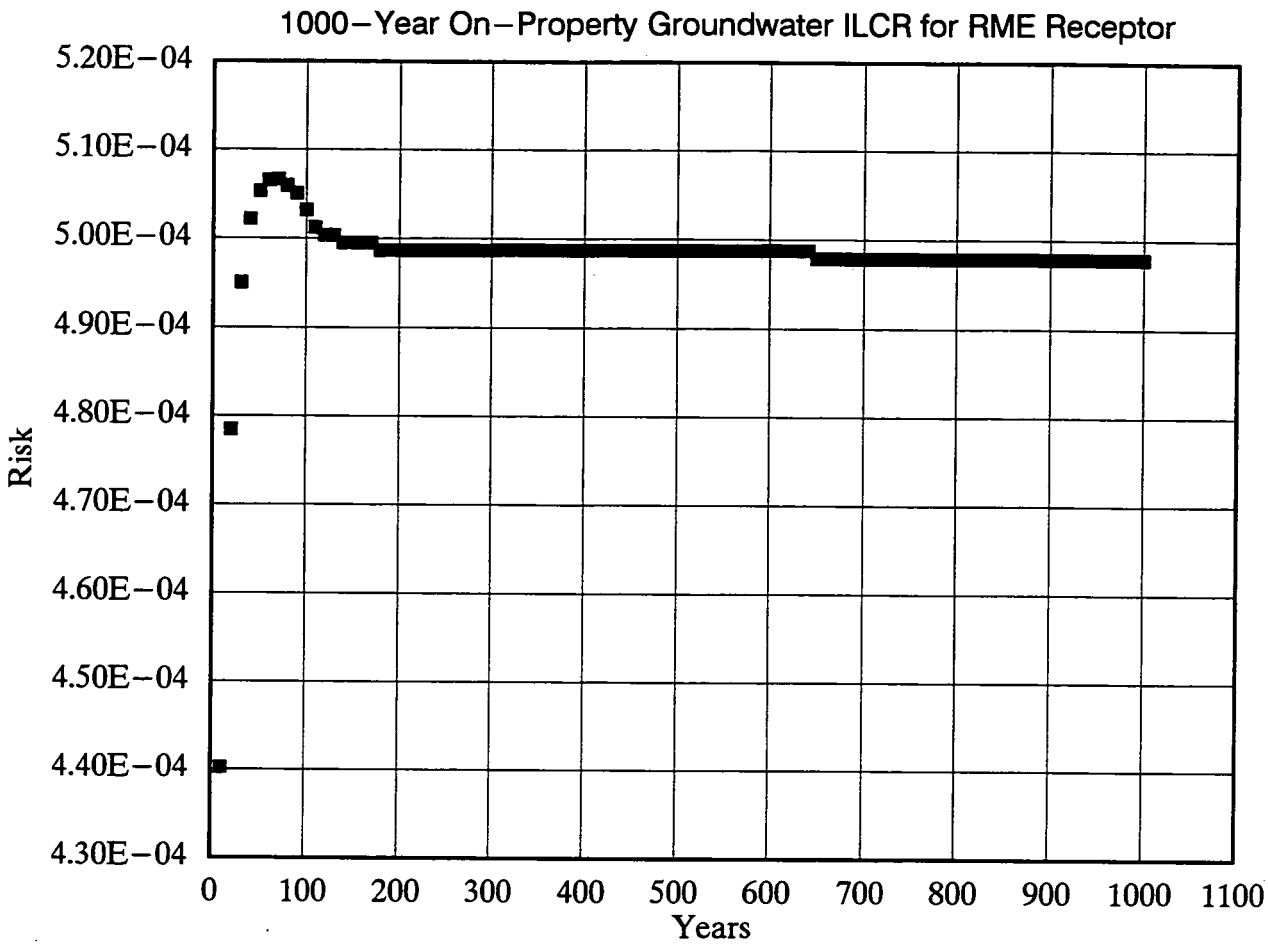
IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	880	6.2E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	880	7.8E-09	5.4E-07	5.6E-07	3.3E-07	8.9E-09	3.4E-09	3.5E-07	1.8E-06		
40	60	880	4.4E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	880	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	880	7.4E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	880	2.8E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	880	5.0E-04
35	56	890	6.3E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	890	7.8E-09	5.4E-07	5.6E-07	3.2E-07	8.5E-09	3.3E-09	3.4E-07	1.8E-06		
40	60	890	4.5E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	890	9.4E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	890	7.6E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	890	2.9E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	890	5.0E-04
35	56	900	6.4E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	900	7.8E-09	5.4E-07	5.6E-07	3.1E-07	8.2E-09	3.2E-09	3.2E-07	1.8E-06		
40	60	900	4.6E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	900	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	900	7.8E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	900	3.0E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	900	5.0E-04
35	56	910	6.5E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	910	7.8E-09	5.4E-07	5.6E-07	3.0E-07	7.9E-09	3.0E-09	3.1E-07	1.7E-06		
40	60	910	4.6E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	910	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	910	8.1E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	910	3.0E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	910	5.0E-04
35	56	920	6.6E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	920	7.8E-09	5.4E-07	5.6E-07	2.9E-07	7.6E-09	2.9E-09	3.0E-07	1.7E-06		
40	60	920	4.7E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	920	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	920	8.3E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	920	3.1E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	920	5.0E-04
35	56	930	6.8E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	930	7.8E-09	5.4E-07	5.6E-07	2.7E-07	7.3E-09	2.8E-09	2.9E-07	1.7E-06		
40	60	930	4.7E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	930	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	930	8.5E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	930	3.1E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	930	5.0E-04
35	56	940	6.8E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	940	7.8E-09	5.4E-07	5.6E-07	2.6E-07	7.0E-09	2.7E-09	2.8E-07	1.7E-06		
40	60	940	4.7E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	940	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	940	8.7E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	940	3.1E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	940	5.0E-04
35	56	950	6.9E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.6E-04		
36	84	950	7.8E-09	5.4E-07	5.6E-07	2.5E-07	6.7E-09	2.6E-09	2.7E-07	1.6E-06		
40	60	950	4.8E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	950	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	950	8.9E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	950	3.2E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	950	5.0E-04

INCREMENTAL LIFETIME CANCER RISK

IX	IY	Time (yr)	Aroclor-1221	NP-237	TC-99	U-234	U-235	U-236	U-238	Total Receptor Risk	10 Year Interval	Off-Property Max 10 Year Risk
35	56	960	7.0E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.5E-04		
36	84	960	7.8E-09	5.4E-07	5.6E-07	2.4E-07	6.5E-09	2.5E-09	2.6E-07	1.6E-06		
40	60	960	4.8E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	960	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	960	9.1E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	960	3.2E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	960	5.0E-04
35	56	970	7.1E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.5E-04		
36	84	970	7.8E-09	5.4E-07	5.6E-07	2.4E-07	6.3E-09	2.4E-09	2.5E-07	1.6E-06		
40	60	970	4.9E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	970	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	970	9.3E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	970	3.3E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	970	5.0E-04
35	56	980	7.2E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.5E-04		
36	84	980	7.8E-09	5.4E-07	5.6E-07	2.3E-07	6.1E-09	2.3E-09	2.4E-07	1.6E-06		
40	60	980	4.9E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	980	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	980	9.5E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	980	3.3E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	980	5.0E-04
35	56	990	7.3E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.5E-04		
36	84	990	7.8E-09	5.4E-07	5.6E-07	2.2E-07	5.9E-09	2.3E-09	2.3E-07	1.6E-06		
40	60	990	5.0E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	990	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	990	9.7E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	990	3.3E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	990	5.0E-04
35	56	1000	7.3E-11	3.4E-06	1.7E-04	3.9E-05	1.0E-06	4.0E-07	4.1E-05	2.5E-04		
36	84	1000	7.8E-09	5.4E-07	5.6E-07	2.1E-07	5.7E-09	2.2E-09	2.2E-07	1.6E-06		
40	60	1000	5.0E-10	6.8E-07	3.4E-05	7.7E-06	2.0E-07	7.9E-08	8.1E-06	5.1E-05		
43	91	1000	9.5E-09	1.1E-06	2.6E-09	2.5E-05	6.6E-07	2.5E-07	2.6E-05	5.3E-05		
47	55	1000	9.9E-10	6.9E-06	3.3E-04	7.7E-05	2.0E-06	7.9E-07	8.0E-05	5.0E-04		
57	71	1000	3.4E-09	3.0E-07	1.9E-07	1.9E-06	5.0E-08	1.9E-08	2.0E-06	4.4E-06	1000	5.0E-04

1000 Year Maximum Risk - 5.1E-04

10 year intervals and receptor location used are indicated by bold lettering.


1000-Year On-Property Groundwater ILCR for RME Receptor
5.20E-04
5.10E-04
5.00E-04
4.90E-04
4.80E-04
4.70E-04
4.60E-04
4.50E-04
4.40E-04
4.30E-04
Risk
0
100
200
300
400
500
600
700
800
900
1000
1100
Years

Average Groundwater Contaminant Concentrations – On–Property (1000 Years)

IX	IY	Time (yr)	Aroclor–122 PPB=ug/l	Antimony PPB=ug/l	Cadmium PPB=ug/l	NP–237 PPB=ug/l	TC–99 PPB=ug/l	U234 PPB=ug/l	U235 PPB=ug/l	U236 PPB=ug/l	U238 PPB=ug/l
47	55	40	2.50E–33	8.70E–01	3.08E–28	7.08E–04	3.08E–01	1.61E–02	1.23E+00	1.73E–02	1.78E+02
47	55	50	5.09E–30	1.02E+00	3.29E–25	7.59E–04	3.08E–01	1.63E–02	1.25E+00	1.76E–02	1.81E+02
47	55	60	2.18E–27	1.15E+00	8.62E–23	7.95E–04	3.08E–01	1.64E–02	1.26E+00	1.77E–02	1.82E+02
47	55	70	3.14E–25	1.26E+00	8.45E–21	8.20E–04	3.08E–01	1.64E–02	1.26E+00	1.77E–02	1.82E+02
47	55	80	2.02E–23	1.37E+00	4.00E–19	8.39E–04	3.08E–01	1.63E–02	1.25E+00	1.76E–02	1.81E+02
47	55	90	7.08E–22	1.47E+00	1.09E–17	8.52E–04	3.08E–01	1.62E–02	1.24E+00	1.75E–02	1.80E+02
47	55	100	1.53E–20	1.56E+00	1.90E–16	8.62E–04	3.07E–01	1.62E–02	1.23E+00	1.74E–02	1.79E+02
Ave Conc @ (47,55)			2.29E–21	1.24E+00	2.88E–17	8.05E–04	3.08E–01	1.63E–02	1.24E+00	1.75E–02	1.80E+02