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Weldon Spring Site Remedial Action Project

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NOTATION — VOLUME II

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document. Acronyms used in tables only are defined in the respective tables.

ACRONYMS, INITIALISMS, AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BA	baseline assessment
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended
CFR	Code of Federal Regulations
CSR	Code of State Regulations
DAC	derived air concentration
DCG	derived concentration guide
DNB	dinitrobenzene
DNT	dinitrotoluene
DOE	U.S. Department of Energy
EA	environmental assessment
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FS	feasibility study
HEPA	high-efficiency-particulate-air (filter)
ICRP	International Commission on Radiological Protection
MCL	maximum contaminant level
MDOC	Missouri Department of Conservation
MSA	material staging area
NAAQS	National Ambient Air Quality Standards
NB	nitrobenzene
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act of 1969
NESHAPs	National Emission Standard for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NORM	naturally occurring radioactive material
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEL	permissible exposure limit
PM-10	particulate matter with an aerodynamic mean diameter of ≤10 μm

RCRA	Resource Conservation and Recovery Act, as amended
REL	recommended exposure limit
RfD	reference dose
RI	remedial investigation
RSMo.	Revised Statutes of Missouri
STAR	stability array
Stat.	Statute
SWDA	Solid Waste Disposal Act, as amended
TBC	to-be-considered (requirement)
TCLP	toxicity characteristic leachate procedure
TI	transport index
TLV	threshold limit value
TNB	trinitrobenzene
TNT	trinitrotoluene
TSA	temporary storage area
TSCA	Toxic Substances Control Act
TSP	total suspended particulates
UL_{95}	95% upper confidence limit of the arithmetic average
UMTRA	Uranium Mill Tailings Remedial Action Project
USC	United States Code
VOC	volatile organic compound

UNITS OF MEASURE

°C	degrees Celsius
°F	degrees fahrenheit
°K	degrees Kelvin
Btu	British thermal unit
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
d	day
dBA	decibel, A-weighted
dL	decaliter
ft	foot
ft^2	square foot
ft^3	cubic foot
g	gram
gal	gallon
gpd	gallon per day
gpm	gallon per minute
h	hour
ha	hectare
in.	inch
kg	kilogram
km	kilometer
km^2	square kilometer
L	liter
lb	pound
µCi	microcurie
µg	microgram
µm	micrometer
µR	microroentgen
m	meter
m^2	square meter
m^3	cubic meter
mCi	millicurie
MeV	million electron volts
mg	milligram
mi	mile
mi^2	square mile
min	minute
mL	milliliter
mm	millimeter
mph	mile per hour
mR	milliroentgen
mrad	millirad
mrem	millirem
pCi	picocurie
ppb	part per billion
ppm	part per million
rad	radiation absorbed dose
rem	roentgen equivalent man
s	second
t	metric ton
WL	working level
WLM	working-level month
WLR	working-level ratio
yd	yard
yd^2	square yard
yd^3	cubic yard
yr	year

ENGLISH/METRIC AND METRIC/ENGLISH EQUIVALENTS

In this document, units of measure are presented with the metric equivalent first, followed by the measured English unit in parentheses. In cases where the measurement was originally made in metric units, the values were not converted back to English units; in tables, the data are generally in English or metric units only. The following table lists the appropriate equivalents for English and metric units.

Multiply	By	To Obtain
English/Metric Equivalents		
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		
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)

APPENDIX A:

SUMMARY OF THE SCOPING PROCESS

APPENDIX A:

SUMMARY OF THE SCOPING PROCESS

A.1 BACKGROUND

The U.S. Department of Energy (DOE) issued a draft environmental impact statement (EIS) in February 1987 to assess the environmental impacts of alternatives for long-term management of contaminated materials associated with remedial action activities at the Weldon Spring site in St. Charles, Missouri (DOE 1987). A Notice of Intent to prepare this draft EIS was issued on March 2, 1984, in the *Federal Register*, and a public scoping process was conducted. The draft EIS was prepared taking into account the comments received during the scoping process. Based on public and technical scoping input, DOE decided to take the "tiered" approach recommended by the Council on Environmental Quality (CEQ) under its regulations for implementing the National Environmental Policy Act (NEPA). The EIS was intended to support the major decisions on cleanup and long-term management of the contaminated materials at the Weldon Spring site, which consists of (1) the chemical plant area which contains the chemical plant and four raffinate pits, and (2) the quarry. Also included within the scope of this EIS was management of materials associated with remediation of contaminated vicinity properties. However, because many of the issues associated with decontamination and decommissioning of the chemical plant were not yet ready for a decision at the time the draft EIS was prepared, cleanup of the chemical plant was to be covered in a separate NEPA document tiered to the EIS.

Following publication of the draft EIS, significant new information became available that was relevant to environmental concerns and the Weldon Spring site, i.e., information indicating that the groundwater beneath the chemical plant area contained elevated concentrations of nitrates and nitroaromatic compounds. In response to this development, DOE announced in June 1987 its intent to issue for public comment a revised draft EIS that would incorporate the new information. Subsequent to this decision, Region VII of the U.S. Environmental Protection Agency (EPA) formally requested that DOE prepare a remedial investigation/feasibility study (RI/FS) for the Weldon Spring site, pursuant to the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. An RI/FS has been prepared in accordance with EPA guidance, incorporating NEPA values at a level appropriate for an EIS, and the document package is termed the RI/FS-EIS. This approach is consistent with DOE policy to integrate NEPA values with CERCLA requirements into one environmental review process to minimize the preparation of duplicate documentation, avoid unnecessary expenditures, and facilitate implementation of environmentally responsive cleanup activities. The contents of the documents comprising the RI/FS-EIS for the chemical plant area are not intended to represent a statement on the legal applicability of NEPA to remedial actions conducted under CERCLA.

A major element of both the CERCLA and NEPA processes is scoping. Scoping is conducted to (1) identify the types of actions that may be required to address site problems, (2) identify the interim actions necessary or appropriate to mitigate potential threats, prevent further environmental degradation, or significantly reduce risks, (3) identify the optimal sequence of site actions and investigative activities, and (4) obtain public input. This appendix summarizes the results of the scoping process for the Weldon Spring site.

A.2 SCOPING PROCESS

In accordance with CEQ regulations and DOE guidelines for implementing NEPA, a scoping process was conducted in 1984 to determine the alternatives to be analyzed in the EIS, the issues to be addressed in the EIS, and the issues to be eliminated from further study.

Public input to this scoping process included:

- Presentations made at a public meeting held at Francis Howell High School on March 20, 1984; and
- Letters received by DOE regarding the scope of the EIS.

The persons and organizations who provided input during this scoping process are listed in Table A.1. Considerable input was received from private citizens; organized citizen action groups (particularly the St. Charles Countians Against Hazardous Waste); local, state, and national political representatives; and state government agencies. Technical input to the scoping process included:

- Preliminary engineering evaluations of several alternatives for disposal of wastes generated by remediating the Weldon Spring site;
- Meetings, correspondence, and review of alternatives and issues by various groups within DOE regarding location and conceptual designs for long-term management of the wastes;
- Preliminary evaluation and — in consultation with Missouri state agencies, local government representatives, and members of the St. Charles Countians Against Hazardous Waste — development of a conceptual design for an above-grade disposal cell at the Weldon Spring site;
- Meetings with Missouri state agencies and elected officials; and
- Meetings with EPA Region VII.

The draft EIS was issued in February 1987 based, in part, on input received during the scoping process. A public comment period followed issuance, as mandated by CEQ regulations for implementing the procedural provisions of NEPA (Title 40, Code of Federal Regulations, Part 1503.1 [40 CFR 1503.1]). As part of the public review process, a public hearing was held on April 10, 1987, at Hollenbeck Junior High School in Harvester, Missouri. Comments on the draft EIS were provided orally at the public hearing, in written material provided to DOE at the public hearing, and in individual letters sent to the DOE Weldon Spring site project office. The persons and organizations who provided comments on the draft EIS are listed in Table A.2. Responses to the major issues raised on the draft EIS are given in Appendix B of the RI/FS-EIS work plan (Peterson et al. 1988). All comments on the draft EIS were treated as scoping input for the RI/FS-EIS.

TABLE A.1 Participants in the Scoping Process Conducted in 1984

Oral Comments, Weldon Spring Public Scoping Meeting, March 20, 1984

Kenneth Rothman, Lt. Gov., State of Missouri
Joseph R. Ortwerth, State Representative, 18th District
Richard Roehl, State Representative, 21st District
Fred Lafser, Missouri Department of Natural Resources
Gary Elmestad, Staff Assistant to Congressman Robert A. Young, 2nd District
Fred Dyer, State Senator, 2nd District
John R. Crellin, Missouri Department of Health
Leann Stevens, St. Charles Countians Against Hazardous Waste
Mary A. Halliday, Defiance
Richard M. Green, St. Charles County Administrative Court
Peggy Coppage, St. Charles County Administrative Court
Thomas Closier, St. Charles County Administrative Court
Meredith Bollmeier, St. Charles Countians Against Hazardous Waste
James Whitley, Missouri Department of Conservation
Dan Olef, Washington University, St. Louis
Wallace Howe, Missouri Department of Natural Resources, Division of Geology and Land Survey
Pamela Armstrong, League of Women Voters of the St. Charles Area
Bobbie Judge, St. Charles Countians Against Hazardous Waste
Robert M. Wester, R.M. Wester & Associates
Thomas J. Aley, Ozark Underground Laboratory
William T. Rebore, Francis Howell School District
Dominick Ferranto, Jr., St. Peters
Kenneth F. Gronewald, St. Peters
Sandy Tabaka, St. Charles County
Sharon Rogers, Missourians Against Hazardous Waste, Warren County
Kay Drey, University City
Bernard Iffrig, St. Peters Old Town Association

Written Comments

Tom Nash, Columbia Field Office, U.S. Fish and Wildlife Service
Mary A. Halliday, Defiance
Kay Drey, University City
Charles Hajnirian, U.S. Environmental Protection Agency, Region VII
Ann Hood, St. Charles Countians Against Hazardous Waste
Aimee Judge, St. Charles
Richard C. Rice, Missouri Emergency Management Agency
Al and Linda Hoenig, St. Peters
Bernard J. Iffrig, St. Peters
Robert A. Young, U.S. Congressman, 2nd District
Fred Dyer, State Senator, 2nd District
Richard O. Olson, Jr., St. Charles Clinic, Inc.
William T. Rebore, Francis Howell School District
Michael V. Garvey, St. Charles

TABLE A.2 Commenters on the Draft EIS

Oral Comments, Public Hearing on the Draft EIS, April 10, 1987

Fred Dyer, State Senator, 2nd District
Joseph Ortwerth, State Representative, 18th District
Craig Kilby, State Representative, 21st District
George Dames, State Representative, 17th District
Jane Schmidt, Western District Commissioner, St. Charles County
Nancy Becker, Eastern District Commissioner, St. Charles County
Tom Owens, Alderman, City of St. Peters
Thomas W. Brown, Mayor, City of St. Peters
Fred Brunner (for John Aschroft, Governor)
Fred Brunner, Missouri Department of Natural Resources
Fred Bronson, St. Charles
John Crellin, Missouri Department of Health
William H. Dieffenbach, Missouri Department of Conservation
Leon Heath, Soil Consultants, Inc.
William Rebore, Francis Howell School District
Carl Johnson, Pierre, S.D.
John Shocklee, Human Rights Office, Archdiocese of St. Louis
Marty Hayden, Eastern Missouri Group, Sierra Club
Ann Hood, Wentzville
Leann Starr, O'Fallon
Bruce Thomas, St. Peters
George A. Behrens, Glendale
Roger Pryor, Coalition for the Environment
Stephen Kauffman, Coalition for the Environment
Michael Garvey, St. Charles
John C. Soucy, Jr., St. Charles
Evalena Wood, St. Charles County
Rao Ayyagari, Lindenwood College, St. Charles
Jack Sanford, St. Charles
Tom Aley, Ozark Underground Laboratory, Protem
Lisa Gruenloh, Francis Howell High School
Stan Pogue, St. Charles (for John Gofman)
Michael Hrdlicka, Francis Howell High School
Terry Mangan, New Melle
Meredith Bollmeier, St. Charles Countians Against Hazardous Waste
Lily Trimble, Coalition for the Environment
George Oliver, Chesterfield
Arlene Sandler, University City
Kay Drey, University City
Rebecca Selove, Community Mental Health Center, St. Charles
Mary Halliday, St. Charles Countians Against Hazardous Waste
Bobbie Judge, St. Charles
Beatrice Buder, Clayton
Byron Clemens, Academy of Mathematics and Science
Katherine McDaniel, St. Louis (for Rex Couture)
Dan Vornberg, Doe Run Company
Martin Pultman, Chesterfield

TABLE A.2 (Cont.)

Oral Comments (Cont.)

Lee Swendsen, St. Charles County
Katherine Swendsen, St. Charles County
Lucy P. Clements
Tom Henkey, Francis Howell High School
John Gestrich, St. Louis
David Lobbig, University City (for Lou P. Kimmell)
Marcus Jackman, Francis Howell High School
Daniel Romano, St. Louis

Written Comments

Frederick A. Brunner, Missouri Department of Natural Resources, Jefferson City
Allen W. Hatheway, Department of Geological Engineering, University of Missouri-Rolla
R. Roger Pryor and Stephen E. Kauffman, Coalition for the Environment, St. Louis
Virginia D. VandenBroek, St. Charles
Paul F. Larson, Soil Conservation Service, Columbia
Virgil Aubuchon
Mark and Sharon Cherry, Weldon Spring
Marcia L. Allmon, Marthasville
Cynthia Fels, Defiance
Michael V. Garvey, St. Charles
George A. Behrens, Glendale
Richard O. Olson and Gary J. Meltz, St. Joseph Health Center, St. Charles
Joan Beauchamp, Wentzville
Donna Owens, Harvester
Richard Christensen, St. Louis
Wayne Muri, Missouri Highway and Transportation Commission, Jefferson City
Charles L. Cronin, St. Peters
John C. Villiforth, Food and Drug Administration, Rockville, Md.
Robert S. Wilkerson, Federal Emergency Management Agency, Washington, D.C.
John C. Soucy, Jr., St. Joseph Health Center-Hospital West, St. Charles
Harold L. Volkmer, House of Representatives, Washington, D.C.
Stephan G. Heitkamp, Clerk, Board of Trustees, Town of Weldon Spring Heights, St. Charles
Barbara J. Ritchie, Washington Department of Ecology, Olympia
Diane Warmann, St. Charles
Pat Allison, St. Charles
Sydney S. Koegler, Richland, Wash.
Robert G. Harmon, Missouri Department of Health, Jefferson City
Larry R. Gale, Missouri Department of Conservation, Jefferson City
Dean Olson, New Mexico Department of Finance and Administration, Santa Fe
Leann M. Starr, O'Fallon
Dennis Kehoe, Marthasville
Ruby E. Quarterman, St. Charles
Catherine Bell, St. Louis
Thomas B. Reth, Department of the Army, Fort Leonard Wood

TABLE A.2 (Cont.)

Written Comments (Cont.)

Ann Hood, Wentzville
Robert H. Toomey, Overland
David M. Cochran, Texas Department of Health, Austin
Margaret C. Burwell, St. Charles
Craig Kilby, Missouri House of Representatives, Jefferson City
Pat Allison, St. Charles
Rao Ayyagari, Lindenwood College, St. Charles
Evalena Wood, St. Charles
Sue Jerman, St. Peters
Robert P. Wuertenberg
Gary T. and Mary A. Callier, St. Charles
Terry M. Millard
Betty Ackermann, St. Charles
Shirley S. Foster, St. Charles County Extension Center, St. Charles
Carole Leriche, St. Charles County Extension Center, St. Charles
Lillie C. Trimble, Parkville
John C. Danforth, U.S. Senate, Washington, D.C.
Steven P. Adams, St. Charles
Mary A. Halliday, St. Charles Countians Against Hazardous Waste, Defiance
Jack C. Sanford, St. Charles
Leon W. Heath, Soil Consultants, Inc., St. Peters
Bobbie Judge, St. Charles
George A. Farhner, St. Charles
Meredith A. Bollmeier, St. Charles
Morris Kay, U.S. Environmental Protection Agency, Kansas City, Kans.
Bruce Blanchard, U.S. Department of the Interior, Washington, D.C.
Pamela J. Fish, St. Peters
Terry Sova, St. Charles
St. Charles County Commission, St. Charles

A.3 ISSUES ADDRESSED IN THE RI/FS-EIS

The issues addressed in the RI/FS-EIS and supporting documents were developed on the basis of public and technical input received during the scoping process. They are issues that were raised during the initial scoping process in 1984, during the public comment period on the draft EIS in 1987, and in subsequent discussions with EPA Region VII and Missouri state officials. These issues are identified in Appendix A of the RI/FS-EIS work plan (Peterson et al. 1988). Since issuance of the work plan, DOE has held numerous briefings and meetings with public officials, school officials, special interest groups, and members of the general public. These meetings, which are generally informal, have allowed for an effective exchange of information and receipt of public input. Hence, the scoping issue associated with DOE interaction with citizen action groups is considered to be resolved and is not addressed further in the RI/FS-EIS.

In addition, the scope of the remedial action addressed in this RI/FS-EIS has been modified since issuance of the work plan as a result of discussions with local, state, and federal regulatory agencies. Specifically, the decision for contaminated groundwater at the chemical plant area is being deferred to a separate operable unit action so that the ongoing characterization of this medium can be completed. Therefore, scoping issues associated with the contaminated groundwater are not addressed in this RI/FS-EIS; rather, they will be addressed in the RI/FS to be prepared for that operable unit. Similarly, the scoping issue associated with future uses of the St. Charles County well field located southeast of the quarry will be addresseed in the RI/FS to be prepared for the separate operable unit that addresses residual contamination at the quarry following removal of the bulk waste; this operable unit includes contaminated vicinity properties and groundwater at the quarry (see Section A.4). The documents that will be prepared for future actions will be written to include NEPA values wherever practicable.

Since the work plan was issued in 1988, a number of workers (and families) have moved to the Weldon Spring area to work on the project. About 200 workers are currently employed at the site. During the cleanup period, fewer than 100 remedial action workers would be involved in on-site activities at any given time. These workers would likely be hired from the labor pool of the greater St. Louis metropolitan area. The socioeconomic issues associated with the impacts of this project on local, municipal, and community services (such as schools and governmental organizations) are not addressed further in this RI/FS-EIS because no significant numbers of workers are expected to move into the area beyond those who have already relocated. Similarly, no significant community impacts would occur after the project is completed because the workers (and their families) who have relocated to the area to work on this project are spread throughout the nearby communities and represent a very small fraction of the population in the surrounding area (e.g., the population of St. Charles County is about 210,000).

The issues addressed in the RI/FS-EIS as a result of scoping input are summarized below.

1. Potential radiological impacts:

   - On people — including workers and the general public.
   - On students and staff at the Francis Howell High School.
   - In terms of both radiation doses and resulting health risks.
   - Associated with various pathways to humans.
   - In the vicinity of the Weldon Spring site, along transportation routes, and near any alternative disposal site.
   - Associated with both routine operations and accidents, including transportation accidents.
   - Associated with off-site migration of radioactive materials.

- Of radionuclide releases due to natural processes such as erosion or seismic activity.
- Associated with human intrusion into the contaminated materials.
- On wildlife in the area.

2. Potential chemical impacts associated with the same categories as potential radiological impacts, consistent with the state of scientific knowledge regarding the toxicological effects of various chemical species.

3. Potential engineering and technical issues:

   - Associated with engineering technologies for management of the contaminated materials.
   - Related to the probable duration of isolation of the contaminated materials, and rate and magnitude of loss of containment — including the ability to monitor and control seepage and contaminant releases from the containment facility and the ability to repair weaknesses or failures in containment.
   - Associated with site geology as related to engineering requirements.
   - Related to characterization of the amounts and types of contaminated materials.
   - On specific transportation routes, modes, and packaging.
   - Related to recovery of potentially valuable materials from the raffinate pit sludge.
   - On the effects of catastrophic natural events such as tornadoes, intense rains, droughts, and floods.
   - Associated with requirements for controlling surface water runoff from the site during construction activities.

4. Potential geological and hydrological issues:

   - Associated with site-specific geological and hydrological conditions.
   - On the history of seismic activity in the area and the potential for future activity.
   - Related to potential for contamination of groundwater from waste disposal activities.

5. Potential institutional issues:

   - Related to criteria for decontamination, effluents, environmental concentrations, and releases of areas for unrestricted or restricted uses.
   - Associated with compliance requirements for state and local laws and regulations.
   - Associated with environmental and safety standards during remedial action activities.
   - On future institutional requirements related to monitoring and maintenance activities.
   - Associated with institutional factors that need to be resolved before an alternative can be implemented.
   - Related to post-action uses of the Weldon Spring site.
   - Associated with potential loss of institutional control.

6. Potential issues relative to mitigative measures and monitoring:

   - On measures to control dispersion of contaminants to the environment.
   - Related to monitoring and maintenance needs during the remedial action period and following completion of remedial action activities.
   - On measures that would be taken to reduce impacts under each alternative.

7. Potential socioeconomic impacts:

   - On current and future local employment, local population growth, and nearby industrial and commercial operations.
   - On local transportation systems.
   - On current and future land use in the vicinity of the Weldon Spring site, including long-term use of site areas.
   - Related to costs of implementing the various alternatives.

8. Miscellaneous issues:

   - Related to the commitment or loss of resources.
   - On worker safety.
   - Associated with site-specific meteorological conditions.
   - Related to mitigative measures to protect potential cultural resources.

A.4 ISSUES BEYOND THE SCOPE OF THE RI/FS-EIS

The following issues are beyond the scope of the RI/FS-EIS.

1. *Psychological impacts* — In light of a U.S. Supreme Court case involving the proposed restart of one of the Three Mile Island reactors (Metropolitan Edison Company vs. People Against Nuclear Energy [PANE] 103 S. Ct. 1556 [1983]), DOE considers only psychological impacts that bear a close causal relationship to the physical environment in environmental compliance documents. Psychological impacts raised to date relative to the Weldon Spring site do not bear such a relationship.

2. *Impacts of past operations at the site* — The impacts of the various alternatives on the existing environment were assessed in the RI/FS-EIS. In the above-mentioned Supreme Court decision, it was stated that "NEPA is not directed at the effects of past accidents and does not create a remedial scheme for past federal actions." Therefore, a detailed analysis of past operations, beyond that necessary to characterize the existing environment, is considered to be beyond the scope of the RI/FS-EIS.

3. *Monitoring of health of students and staff at Francis Howell High School* — An ongoing environmental monitoring program is being conducted by DOE in the vicinity of the Weldon Spring site. This program includes the Francis Howell High School area. No additional monitoring studies of students and staff at the Francis Howell High School will be performed as part of the RI/FS-EIS process because the ongoing environmental monitoring program demonstrates that individuals at the high school are not being exposed to measurable levels of radioactive or chemical contaminants originating from the Weldon Spring site. However, potential health impacts on students and staff are addressed in the RI/FS-EIS.

4. *Excavation, transport, and temporary storage of quarry bulk wastes* — The DOE has addressed the removal of the quarry bulk wastes as a separate operable unit and has prepared an RI/FS to support this decision. The record of decision for this operable unit was signed by EPA Region VII on September 28, 1990.

5. *Removal of residual contamination from the quarry* — After the bulk wastes have been removed from the quarry, the quarry will be inspected to determine if additional remedial action is required. The need for any additional remedial action at the quarry cannot be determined prior to bulk waste removal and inspection of the resultant conditions in the quarry. This issue is therefore beyond the scope of the RI/FS-EIS.

6. *Remediation of contaminated groundwater and vicinity properties at the quarry area* — A decision to remediate contaminated groundwater and vicinity properties at the quarry area (i.e., Femme Osage Slough) is beyond the scope of the RI/FS-EIS. The DOE will address the issue of contaminated groundwater and vicinity properties at the quarry area following removal of the bulk wastes from the quarry.

7. *Remediation of contaminated groundwater at the chemical plant area* — The DOE is addressing the contaminated groundwater at the chemical plant area as a separate operable unit; an RI/FS will be prepared for this operable unit within the next several years. This approach for managing contaminated groundwater, which was developed in consultation with EPA Region VII and the state of Missouri, will allow for additional characterization data to be obtained prior to reaching a decision. Addressing groundwater as a separate operable unit will also allow for additional coordination to take place with the Army, which is responsible for the adjacent National Priorities List site also having groundwater contamination.

8. *Remediation of the Southeast Drainage* — The Southeast Drainage is a natural channel that drains surface runoff from the southeast portion of the chemical plant area to the Missouri River. The decision for this drainage is being deferred because conditions are expected to change as a result of ongoing and planned cleanup actions at the site. Additional sampling will be conducted over the next several years to fully characterize the drainage and support the future decision for this vicinity property.

9. *Other radioactively contaminated sites in the St. Louis area* — The EPA Region VII proposed in 1984 that DOE also consider the possibility of cumulative disposal at the Weldon Spring site of the radioactive wastes currently stored at various locations in Missouri. These wastes and their locations are as follows:

   - St. Louis Downtown Site and vicinity properties — previously used to process uranium ore and concentrates to produce uranium dioxide, uranium trioxide, uranium tetrafluoride, and uranium metal; the site was also previously used for other activities associated with uranium metal and for extraction and concentration of thorium-230 from pitchblende raffinates.

   - St. Louis Airport Site and vicinity properties — previously used for storing ore residues, scrap, and equipment from uranium-processing operations.

- Latty Avenue Properties — previously used for storing ore residues and wastes from uranium-processing operations.
- West Lake Landfill — previously used for disposing of contaminated soil from the property at 9200 Latty Avenue.

The St. Louis Downtown Site and vicinity properties, St. Louis Airport Site and vicinity properties, and Latty Avenue Properties are already included in the DOE Formerly Utilized Sites Remedial Action Program; the West Lake Landfill is under the cognizance of the U.S. Nuclear Regulatory Commission. The DOE has no plans to dispose of these wastes at the Weldon Spring site. Therefore, the cumulative impacts from disposal of the wastes from other sites in the St. Louis area at the Weldon Spring site are not addressed in the RI/FS-EIS.

A.5 REFERENCES

Peterson, J.M., et al., 1988, *Work Plan for the Remedial Investigation/Feasibility Study-Environmental Impact Statement for the Weldon Spring Site, Weldon Spring, Missouri*, DOE/OR/21548-033, prepared by Argonne National Laboratory, Energy and Environmental Systems Division, Argonne, Ill., for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, St. Charles, Mo., Aug.

U.S. Department of Energy, 1987, *Draft Environmental Impact Statement, Remedial Action at the Weldon Spring Site*, DOE/EIS-0117D, Office of Remedial Action and Waste Technology, Feb.

APPENDIX B:

TECHNOLOGY MATRIX

APPENDIX B:

TECHNOLOGY MATRIX

B.1 EVALUATION OF POTENTIAL TECHNOLOGIES

Alternatives for remedial action at a contaminated site can be developed using a three-tiered process. This process (1) identifies general response actions that can be conducted for contaminated media at the site, (2) considers the potential applicability of various technologies associated with each response action, and (3) indicates individual process options within each technology category that could be implemented to best achieve the remedial action objectives and goals for site cleanup.

To initiate this process, a basic technology matrix was prepared from which comprehensive remedial action alternatives could be developed for the Weldon Spring site. The matrix, which is presented in this appendix, identifies (1) general response actions, such as treatment; (2) technology types, such as chemical stabilization/solidification; and (3) process options, such as cement-based pozzolanic reactions in a pug mill mixer, that could be used for each contaminated medium at the site. The media are grouped for consideration as follows: soil, sludge, and sediment are addressed in Table B.1; surface water is addressed in Table B.2; groundwater is addressed in Table B.3; and structural material, process chemicals, and vegetation are addressed in Table B.4.

Groundwater is beyond the scope of the current remedial action because it is being addressed as a future operable unit of the site's comprehensive cleanup. Therefore, the discussion of potential responses, technologies, and process options in Table B.3 is limited. Information is presented in this table to (1) identify interim activities that would apply, such as institutional control measures, and (2) support the consideration of a contingency response in the event that localized action might be necessary (e.g., to address perched groundwater that might be present beneath the raffinate pits).

Similar to the grouping of media, other components of this matrix have also been grouped to facilitate the presentation. For example, treatment as a general response is grouped on the basis of its application in situ or following removal; the technology types for treatment are grouped according to physical, chemical, and biological processes; and the process options — i.e., the specific methods by which a type of treatment can be achieved — are listed and discussed together. Information for the technology matrix was compiled from reports of the U.S. Environmental Protection Agency (1985, 1987, 1988a, 1988b, 1989, 1990), Ehrenfeld and Bass (1984), Goldman et al. (1986), and Holden et al. (1989).

This matrix provides basic technical information that was used to support the evaluation of technologies for specific applicability to the Weldon Spring site. In that evaluation, the different options were screened on the basis of three general criteria: effectiveness, implementability, and cost. The site-specific technology evaluation from which preliminary remedial action alternatives were developed is presented in Chapter 3 of this FS.

TABLE B.1 Potential Response Actions and Technologies for Soil, Sludge, and Sediment

General Response Action/ Potential Technology Type	Potential Process Option	Comments
No Action		
Not applicable	Not applicable	The no-action alternative is included to provide a baseline for comparison with action alternatives.
Institutional Control		
Access restrictions	Fences and guards	Access restrictions can mitigate exposures by limiting access and use.
Ownership and use or deed restrictions	Legal titles and deeds	Ownership and use or deed restrictions can mitigate exposures by limiting access and use.
Monitoring	Groundwater wells and air, surface water, and soil/sludge samplers	Monitoring can provide data for assessing the potential for exposure.
In-Situ Containment		
Surface controls/diversions	Graded contours, swales and berms, and vegetation	Surface controls and capping can limit contaminant mobility and mitigate potential exposures, bioupiake, and migration via air, surface water, and groundwater by attenuating gaseous emissions (e.g., radon) and controlling particulate resuspension, surface water runon and runoff, and precipitation-enhanced percolation and leaching from the waste. These processes can be implemented with conventional equipment.
Capping	Soil (clay) and vegetation or riprap; asphalt or cement; synthetic membrane material; and multilayer, multimedia material	
Lateral barriers	Slurry wall, grout curtain, and sheet piling	Lateral barriers and bottom sealing can limit contaminant mobility and mitigate potential exposures by limiting migration to other soil and sludge, groundwater, and surface water (e.g., via groundwater discharge). These technologies can be implemented with conventional equipment, but implementation can be constrained by the size of the affected area and by site-specific hydrogeological conditions. These technologies are not typically used unless the substrate water content is high.
Bottom sealing	Grout layer injection and block displacement	
Removal		
Excavation/dredging	Dragline, backhoe, bulldozer, scraper, and front-end loader; cutting head dredge	Excavation, dredging, and pumping can limit contaminant mobility and mitigate potential exposures and bioupiake at the affected area by removing the contaminant source. These technologies can be implemented with conventional equipment.
Pumping (sludge or slurried soil)	Dynamic (centrifugal), reciprocating, and positive displacement pumps	

TABLE B.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment In Situ		
Physical		
Dewatering/drying	Solar evaporation, pumping, and gravity drainage trenches	Dewatering/drying can limit the mobility and reduce the total volume of contaminated material and mitigate potential exposures, migration, and biouptake at the affected area. These processes can be implemented with conventional methods.
Nonthermal extraction	Air injection, vacuum extraction, and aqueous soil flushing	Nonthermal extraction in situ can reduce the toxicity, mobility, and volume of contaminated material and mitigate potential exposures, biouptake, and migration by physically altering the contaminant source. Air injection and vacuum extraction can be used to treat soil, sludge, and sediment contaminated with volatile organic compounds, but these processes are generally ineffective for treating low-volatile organic compounds and cyanides, metals, and other inorganic compounds. The primary action associated with soil flushing with water is a physical "sweeping" to accelerate contaminant migration by injection (wells) or spraying/ponding (surface application); thus, it is discussed herein as a physical technology. Water alone is typically a poor flushing solution, and this process is generally ineffective for complex wastes or for treating soil with moderate to high adsorption capacity and low permeability.
Thermal extraction	Steam/hot water injection, steam/hot air extraction, radiofrequency heating, and electroacoustic soil decontamination	In-situ thermal extraction can provide results comparable to nonthermal extraction under similar constraints. Steam and hot water can be injected into soil, sludge, or sediment contaminated with oils to enhance their displacement to the surface. Steam and hot air can be used to treat soil, sludge, or sediment contaminated with volatile organic compounds by enhancing their evaporation and upward migration. The radiofrequency heating process is in the developmental stage and can be used to treat soil, sludge, or sediment contaminated with hydrocarbons. Wells, conductors, and electrodes are used in the electroacoustic soil decontamination process to enhance liquid transport (i.e., dewatering/leaching) via soil particle double layer boundary effects; heavy metals may also be leached or precipitated by this process, which is in the developmental stage and has been demonstrated only on a pilot scale for waste treatment applications.

TABLE B.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment In Situ (Cont.)		
Physical (cont.)		
Thermal destruction	In-situ vitrification	In-situ thermal destruction can reduce the toxicity, mobility, and volume of contaminated soil, sludge, and sediment and mitigate potential exposures, biouptake, and migration by physically altering the contaminant source. For in-situ vitrification, an electric current is passed through electrodes to melt the soil, sludge, or sediment and destroy organic compounds by pyrolysis and combustion; upon cooling, a glassy, crystalline matrix is formed that incorporates inorganic contaminants (including radionuclides) and other nonvolatile compounds; field-scale demonstration of in-situ vitrification has been limited (and marred by mishaps such as explosions), and it remains in the developmental stage for waste treatment.
Chemical		
Soil flushing	Acid/base, surfactant, chelating agent, and organic solvent solution via surface application and injection/extraction wells	In-situ chemical flushing can reduce the toxicity, mobility, and volume of contaminated soil, sludge, or sediment via desorptive reactions and mitigate potential exposures, biouptake, and migration by altering the contaminant source. This technology can remove volatile organic compounds from permeable soils (although migration control can be difficult), and it can be used as an initial treatment step to leach contaminants from a waste matrix (e.g., via solution mining). The solubility of hydrocarbons, metals, and radionuclides can be enhanced by solvent application, and the reagent solution can be sprinkled or ponded over the contaminated zone for aggressive treatment. This technology is ineffective for complex wastes (e.g., radionuclides mixed with metals and some organic compounds) because it is very contaminant-specific and the selection of a suitable flushing fluid for a combined waste is difficult. Mobile units are available, but full-scale site cleanup has not yet been demonstrated by these processes.
Chemical addition/detoxification	Hydrolysis, redox reactions, neutralization, precipitation, and solidification	Chemical addition/detoxification can provide results comparable to in-situ soil flushing via chemical reactions that alter the toxic nature of the contaminants or fix them to limit mobility; however, in contrast to soil flushing, these reactions can increase the total volume of contaminated material following chemical addition (e.g., due to precipitation and solidification). Chemical agents can be dispensed through a drill shaft and mixed via an up/down drill motion or by augers and hydraulically driven paddles; reagents are typically selected for treatment specificity. This technology is developmental for waste treatment applications.

TABLE B.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment In Situ (Cont.)		
Chemical (cont.)		
Stabilization/solidification	Lime-based and Portland-cement-based pozzolanic reactions, asphalt-based thermoplastic microencapsulation, and catalyzed polymerization	In-situ stabilization/solidification processes can provide results comparable to in-situ chemical detoxification for solidification. This technology is typically used to treat soil, sludge, or sediment contaminated with heavy metals and high molecular weight organic compounds by binding the contaminants in place in an insoluble matrix or in a matrix that minimizes the surface exposed to potential solvents; drills, augers, and paddles can be used to introduce chemicals. Field demonstration of this technology in waste treatment applications has been limited.
Biological		
Bioreclamation	Nutrient/microbial injection and other system manipulation	In-situ bioreclamation can reduce the mobility and volume of contaminated material and the toxicity of certain chemical contaminants (e.g., some organic compounds) in soil, sludge, and sediment and can limit potential exposures, biouptake, and migration by altering the contaminant source via enhanced biodegradation. In this process, oxygen, water, nutrients, and microbes can be applied to the surface of contaminated soil, sludge, or sediment or injected into the contaminated zone to enhance the natural biodegradation of contaminants; in addition, pH and temperature can be adjusted to improve reaction conditions. Bioreclamation can be used to treat highly biodegradable material, but it is generally ineffective for (and can be adversely affected by) inorganic compounds, including heavy metals and radionuclides. This process is developmental for waste treatment applications (e.g., to treat pesticides and polychlorinated biphenyls [PCBs]), and its applicability can be limited by environmental factors such as hydrogeology, temperature, and pH.
Suspended growth biodegradation	Surface impoundments, such as stabilization pits, lagoons, or wetlands	Surface impoundments can provide results comparable to in-situ bioreclamation under similar constraints. In this process, an in-situ impoundment can be used to promote natural geochemical and biological reactions for removal of surface contamination, including metals. This technology is developmental for waste treatment applications.

TABLE B.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment following Removal		
Physical		
Dewatering/drying	Rotary drum, vacuum, and belt filtration; drying bed; filter press; automatic pressure filtration; gravity thickening; centrifugation; and evaporation	Dewatering/drying can limit the mobility and reduce the total volume of contaminated material and mitigate potential exposures, migration, and biouptake at the affected area. These processes can be implemented with conventional methods.
Solids separation	Classification (mechanical and non-mechanical); soil sorting, sand sifting (with grizzlies), and screening (wet/dry); flotation and gravity concentration/centrifugation; magnetic and paramagnetic separation; and electrostatic separation	Solids separation processes can limit the toxicity, mobility, and volume of contaminated material and mitigate potential exposures, migration, and biouptake. This technology could serve as a pretreatment step for a primary treatment process, and it is considered developmental for waste treatment applications. Although certain solids separation processes have been used to extract radionuclides from original ores, they are generally ineffective for separating relatively low concentrations of contaminants from soil, sludge, or sediment.
Volume reduction	Impact crushers, shredders, pulverizers, grapplers, tumbling and hammer mills, and compactors	These processes can reduce the size and volume of contaminated material (e.g., large chunks of soil or rock), which is often required as a pretreatment step for a primary treatment process (e.g., for a chemical extraction or thermal destruction process).
Nonthermal extraction	Aqueous soil washing in a reactor vessel	Nonthermal extraction following removal can provide results comparable to (and typically better than) nonthermal extraction in situ. Soil, sludge, or sediment can be mixed with water in a contact vessel to wash contaminants from the waste matrix, but water alone is typically ineffective as a washing solution, especially when the waste includes organic compounds, metals, and radionuclides.
Thermal extraction/destruction	Low-temperature thermal stripping; slagging, rotary kiln, and fluidized-bed incineration; vitrification (using a joule-heated or fossil-fuel-heated melter or a plasma arc torch system), pyrolytic incineration/electric pyrolysis, advanced electric reactor, and high-temperature fluid wall reactor; circulating bed and molten salt combustors; and infrared thermal destruction and wet air and supercritical water oxidation in reactor vessels.	Thermal treatment following removal can provide results comparable to (and typically better than) thermal treatment in situ. The various process options usually produce solid (e.g., ash, char, or glass), liquid (e.g., scrubbing water, brine, or condensate), and gaseous (e.g., volatilized organic compounds and metals and innocuous gases) effluents. Thermal destruction processes are typically used to destroy organic compounds; although some are common in waste treatment applications (e.g., incineration), others are developmental (e.g., vitrification, infrared thermal destruction, and supercritical water oxidation) and have been demonstrated only on a pilot scale.

TABLE B.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment following Removal (Cont.)		
Chemical		
Contact extraction	Nonaqueous soil washing, amine extraction, critical fluid solvent extraction (liquefied carbon dioxide and/or propane), and other solution extractions (as for in-situ soil flushing) in a reactor vessel	Chemical extraction following removal can provide results comparable to (and typically better than) in-situ soil flushing. Various solutions can be used to separate oils, organic compounds, radionuclides, and metals from soil, sludge, or sediment in an agitated reactor vessel. Amine extraction can be used to remove organic compounds, and the pH adjustment required for pretreatment may also precipitate heavy metals. Critical fluid solvent extraction can separate oils and organic compounds from sludge, sediment, or slurried soil and has been used to treat PCB-contaminated sludge, but it is inappropriate for removing heavy metals or inorganic compounds.
Chemical addition	Glycolate dechlorination and redox reactions (which may be enhanced by electrolysis, catalysis, or irradiation) in a reactor vessel	Chemical-specific reactions following removal can provide results comparable to (and typically better than) chemical detoxification in situ. Glycolate dechlorination can be used to dehalogenate volatile and semivolatile organic compounds, PCBs, and pesticides by mixing contaminated soil, sludge, or sediment with a glycolate solution in a heated reactor vessel; this process has been tested on PCB-contaminated soil. Reduction and oxidation processes can treat chlorinated organic compounds and unsaturated hydrocarbons, metals, inorganic cyanides, and reactive contaminants in sludge, sediment, or slurried soil. This process might be applicable as a treatment step, but care must be taken to select reagents specific to the reaction required and to avoid undesirable secondary reactions and waste generation.
Stabilization/solidification	Asphalt-based thermoplastic micro-encapsulation, silicate and adsorbent binding, catalyzed polymerization, and lime-based and Portland-cement-based pozzolanic reactions in a reactor vessel such as a pug mill blender	As described for the in-situ application, except that process effectiveness is less constrained because various pretreatment options are available (e.g., dewatering and crushing) and the mix can be better controlled. This technology has been demonstrated for hazardous waste treatment applications and can be implemented with conventional equipment.

TABLE B.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment following Removal (Cont.)		
Biological		
Composting	Open and static windrows and reactor vessels	Organic degradation following removal via composting can provide results comparable to (and typically better than) in-situ bioreclamation under similar constraints. This can be achieved by using open windrows, consisting of long piles of waste that are aerated by alternately tearing down and rebuilding; by using static windrows that are aerated by forced air; and by using reactor vessels that are aerated by tumbling, stirring, and forced air. Composting can be applicable to the treatment of highly biodegradable material and structurally firm waste (e.g., contaminated wood chips; see related discussion in Table B.4).
Suspended growth biodegradation	Continuous-flow stirred tank reactor and plug flow reactor	Suspended growth reactions — such as activated sludge treatment and anaerobic digestion for slurried soil, sediment, and sludge — can provide results comparable to (and typically better than) in-situ bioreclamation under similar constraints. System conditions can be optimized, and cometabolites can be added more easily in a reactor vessel than in situ. These processes might be useful for treating waste contaminated with some pesticides or PCBs. Although these processes are commonly used in conventional wastewater/sludge treatment, they are developmental for hazardous waste treatment applications.
	Surface impoundments, such as constructed stabilization pits, lagoons, or wetlands	As described for the in-situ application, but system construction and control and optimization of treatment conditions are less constrained. For example, a lined treatment bed could be constructed with a leachate collection system and an overhead spray irrigation system to distribute nutrients and microbes. Although developmental for hazardous waste treatment applications, this technology might be useful for treating waste contaminated with some pesticides, PCBs, or oils.
Attached growth biodegradation	Rotating biological contactor, trickling filter, and fixed-film fluidized bed reactor	Attached growth reactions following removal for slurried soil, sediment, and sludge can provide results comparable to (and typically better than) suspended growth reactions following removal, under similar constraints. These processes are not suitable for inorganic-contaminated material, but treatment has been demonstrated for sludge containing biodegradable organic compounds.

TABLE B.1 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment following Removal (Cont.)		
Biological (cont.)		
Land application	Land farming	Land application for slurried soil, sediment, and sludge can provide results comparable to (and often better than) composting under similar constraints. Under this technology, a waste can be applied to and/or mixed with surface soil to enhance natural geochemical and biological processes. Although developmental for hazardous waste treatment applications, these processes might be useful for treating waste contaminated with some pesticides, PCBs, or oils.
Short-Term Storage		
On-site or off-site facility	Land-based engineered structure	Short-term storage can reduce the mobility of contaminated material and mitigate potential exposures, biouptake, and migration by controlling the contaminant source. This option requires the engineering of a storage facility and would be implemented as an interim measure while a permanent remedy was being developed.
Disposal		
On-site or off-site	Land-based engineered structure, such as a sanitary landfill constructed of soil material, a cell constructed of both soil material and synthetic material, or a concrete vault; or ocean disposal	This option requires either the engineering of a land-based disposal facility or administrative permission for implementing ocean disposal (which is highly unlikely). Land-based disposal can reduce the mobility of contaminated material and mitigate potential exposures, biouptake, and migration by controlling the contaminant source. (Disposal often follows the treatment of contaminated material, so toxicity reduction is often inherent in the overall waste management scheme.) In addition to engineering requirements, constraints include issues such as transportation routes, risks, and costs for the off-site option and regulator/community acceptance.

TABLE B.2 Potential Response Actions and Technologies for Surface Water

General Response Action/ Potential Technology Type	Potential Process Option	Comments
No Action		
Not applicable	Not applicable	The no-action alternative is included to provide a baseline for comparison with action alternatives.
Institutional Control		
Access restrictions	Fences and guards	Access restrictions can mitigate exposures by limiting access and use.
Ownership and use or deed restrictions	Legal titles and deeds	Ownership and use or deed restrictions can mitigate exposures by limiting access and use.
Monitoring	Groundwater wells and surface water samplers	Monitoring can provide data for assessing the potential for exposure.
In-Situ Containment		
Surface controls/diversions	Graded contours, swales, dikes, and berms	Surface controls/diversions can limit contaminant mobility and can mitigate potential exposures, biouptake, and migration by controlling surface water runon and runoff from the waste. These processes can be implemented with conventional equipment.
Lateral barriers	Grout layer injection and block displacement	Lateral barriers and bottom sealing can limit contaminant mobility and mitigate potential exposures by limiting migration to underlying soil, surface water, and groundwater. These processes can be implemented with conventional equipment, but field applications can be constrained by the size of the affected area and by site-specific hydrogeological conditions.
Bottom sealing	Slurry wall, grout curtain, and sheet piling	
Removal/Collection		
Interception and pumping	Interceptor channels and dynamic (centrifugal), reciprocating, and positive displacement pumps	Runoff interception and pumping can limit the toxicity, mobility, and volume of contaminated material via removal, thereby mitigating potential exposures, biouptake, and migration at the initial location. This technology can be implemented with conventional equipment and is typically followed by treatment.
Skimming and "sinker" collection	Floating boom and siphon dam	These in-situ processes can reduce the toxicity, mobility, and volume of contaminated surface water and mitigate potential exposures, biouptake, and migration by removing contaminants from the source. They can be implemented with conventional methods and are typically used to remove floating oils or dense ("sinking") contaminants from surface waters (primarily streams).

TABLE B.2 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment In Situ		
Physical		
Nonthermal extraction	Photolysis, filtration, density separation (clarification and flotation), and flocculation	These in-situ processes can reduce the toxicity, mobility, and volume of contaminated surface water and mitigate potential exposures, biouptake, and contaminant migration by physically altering the contaminant source. Such methods include ultraviolet irradiation, filter screening, and enhanced sedimentation using a settling agent and air bubbling or mixing with blades. They can be implemented with conventional methods and are typically used to remove suspended solids.
Thermal extraction	Solar evaporation	Thermal extraction can provide results comparable to nonthermal extraction in situ. Natural irradiation can be enhanced with covers and condensate collection to expedite treatment. This process can be implemented with conventional equipment, but its application is constrained by site-specific climatic conditions.
Chemical		
Chemical addition	Hydrolysis, redox reactions (including ozonation and chlorination), dechlorination, chelation, neutralization, and precipitation	Chemical addition can reduce the toxicity, mobility, and volume of contaminated surface water and mitigate potential exposures, biouptake, and contaminant migration by altering the contaminant source. This is achieved via chemical reactions that change the chemical (toxic) and/or physical nature of the contaminants. Chemical reagents such as surfactants, acids/bases, chelating agents, precipitants, and coagulant/flocculent aids can be mixed into a surface water by mechanical means (e.g., paddles and blades) or by aeration. These processes can be implemented with conventional methods to treat both organic and inorganic compounds and are common in wastewater treatment applications (much more so following removal than in situ); their application for hazardous waste treatment has been limited.
Biological		
Bioreclamation	Nutrient/microbial injection and other system modifications	In-situ bioreclamation can reduce the mobility of contaminants in surface water and the toxicity of certain chemical contaminants, and it can mitigate potential exposures, biouptake, and migration by altering the contaminant source via enhanced biodegradation. In this process, oxygen, nutrients, and microbes can be introduced to the system, and pH can be adjusted with chemical addition to improve reaction conditions; mixing is typically required to enhance degradation. Bioreclamation can be used to treat highly biodegradable material but is generally ineffective for — and can be adversely affected by — inorganic compounds, including heavy metals and radionuclides.

TABLE B.2 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment following Removal		
Physical		
Nonthermal extraction	Density separation (centrifugation), flocculation, filtration, adsorption, osmosis, reverse osmosis/ultrafiltration, electrolysis, electrodialysis, and freeze crystallization	Nonthermal extraction processes following removal can provide results comparable to (and typically better than) nonthermal extraction in situ, with fewer constraints and greater control of reactions and products. The processes can generally be implemented with conventional equipment, and many are used to remove suspended solids. Certain processes have been used in industrial wastewater treatment, but their demonstration in hazardous waste treatment has been limited.
Thermal extraction/ destruction	Stripping, vapor recompression/ distillation, wet air oxidation, supercritical water oxidation, liquid-injection incineration, and chlorinolysis	Thermal extraction and destruction processes can reduce the toxicity, mobility, and volume of contaminated surface water and mitigate potential exposures, biouptake, and migration by altering the contaminant source. These processes are typically used to destroy organic compounds and can be operated with a liquid feed. Although certain destruction processes have been used in industrial applications, their demonstration for hazardous waste treatment has been limited.
Chemical		
Contact extraction	Solvent extraction	Contact extraction can reduce the toxicity, mobility, and volume of contaminated surface water and mitigate potential exposures, biouptake, and migration by altering the contaminant source. Solvent extraction is typically used to remove organic compounds from aqueous solutions and can be implemented with conventional methods. Application for hazardous waste treatment has been limited.
Chemical addition	Hydrolysis, redox reactions (including ozonation and chlorination), dechlorination, chelation, neutralization, precipitation, ion exchange, and adsorption beds, using a reactor vessel	As described for the in-situ application, but the reaction system can be better controlled and process effectiveness can be optimized. Chemical addition can treat both organic and inorganic contaminants and can be implemented with conventional methods. It is commonly used in wastewater treatment applications, but its application for hazardous waste treatment has been limited.

TABLE B.2 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment following Removal (Cont.)		
Biological		
Suspended growth biodegradation	Continuous-flow stirred tank reactor and plug flow reactor	As described for soil, sludge, and sediment following removal (Table B.1).
	Surface impoundments, such as constructed lagoons or wetlands	Surface impoundments can provide results comparable to (and typically better than) in-situ bioreclamation under similar constraints. This process would likely mimic the original condition of the surface water, except that the system could be constructed for better control and optimized to enhance removal efficiency (see the related discussion for soil, sludge, and sediment).
Attached growth biodegradation	Rotating biological contactor, trickling filter, and fixed-film fluidized bed reactor	Attached growth reactions following removal can provide results comparable to (and typically better than) in-situ bioreclamation under similar constraints, but with improved control and optimization. These processes are not suitable for inorganic-contaminated material but could be useful for treating solutions contaminated with biodegradable organic compounds.
Land application	Land farming, spray irrigation, and overland flow	These processes can provide results comparable to surface impoundments and can be achieved using conventional equipment. They can be used to treat organic compounds but are generally ineffective for inorganic compounds, and implementation can be constrained by site-specific hydrogeological conditions.
Short-Term Storage		
On-site or off-site facility	Engineered structure	Short-term storage, e.g., in retention ponds, can reduce the mobility of contaminated water and mitigate potential exposures, biouptake, and migration by controlling the contaminant source. This option requires the engineering of a storage facility and would be implemented as an interim measure while a permanent remedy was being developed.

TABLE B.2 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Disposal		
On-site	Injection to groundwater, or discharge onto land or to some other surface water	Direct disposal following removal, especially when used in conjunction with treatment, can reduce contaminant toxicity, mobility, and volume and mitigate potential exposures, biouptake, and migration at the initial contaminated location. Surface water can be directly injected into the ground, discharged directly onto land (e.g., via spraying or overland flow), or discharged to an on-site surface water impoundment (e.g., by pipe or gravity drainage) following collection.
Off-site	Injection to groundwater; or discharge onto land, to a publicly owned treatment works, or to some other surface water	Off-site disposal can provide results comparable to on-site disposal, with an additional option of piping to a publicly owned treatment works. This option must often be preceded by some type of treatment and requires permission from the operator.

TABLE B.3 Potential Response Actions and Technologies for Groundwater

General Response Action/ Potential Technology Type	Potential Process Option	Comments
No Action		
Not applicable	Not applicable	The no-action alternative is included to provide a baseline for comparison with action alternatives.
Institutional Control		
Access restrictions	Fences or other barriers (such as well caps) at wells/points of discharge	Access restrictions can mitigate exposures by limiting access and use.
Ownership and use or deed restrictions	Legal titles and deeds and drilling restrictions	Ownership and use or deed restrictions can mitigate exposures by limiting access and use.
Monitoring (e.g., of natural attenuation)	Groundwater wells	Monitoring can provide data for assessing the potential for exposure.
Alternate water supply	Piped/transported water from a separate source, such as a surface water or a municipal supply	An alternate water supply is typically an interim measure used to ensure human health while a permanent remedy is being developed.
In-Situ Containment		
Lateral barriers	Slurry wall, grout curtain, and sheet piling	Lateral barriers can limit contaminant mobility and mitigate potential exposures, e.g., from perched groundwater, by limiting migration to uncontaminated groundwater and to surface water via discharge. These processes can be implemented with conventional equipment, but their effectiveness is constrained by the size of the affected area and by site-specific hydrogeological conditions. (Note that insofar as surface controls can limit contaminant migration to groundwater, they may also be considered for groundwater control; see related discussion in Table B.1.)
Bottom sealing	Grout layer injection and block displacement	Bottom sealing can provide results comparable to lateral barriers under similar constraints. This technology might be useful for containment of lenses or shallow aquifers, but its application is constrained by the size of the affected area and by site-specific hydrogeological conditions and it is not typically effective for deep groundwater systems.

TABLE B.3 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Removal/Collection		
Interception and pumping	Subsurface drains and interceptor trenches, wellpoints, suction wells, ejector wells, and deep wells	Groundwater removal by pumps and trenches can limit the toxicity, mobility, and volume of contaminants at the initial location, thereby mitigating potential exposures, biouptake, and migration by altering the contaminant source. These processes can be implemented with conventional equipment, but their effectiveness is constrained by site-specific hydrogeological conditions. (Removal is typically followed by treatment to reduce contaminant toxicity, mobility, or volume in the collected water.)
Treatment/Pretreatment in Situ		
Physical		
Extraction	Air/steam stripping	Extraction can reduce the toxicity, mobility, and volume of contaminants in groundwater and mitigate potential exposures, biouptake, and migration by altering the contaminant source. Stripping can be used to remove volatile organic compounds from groundwater, but it is typically associated with a removal/collection system. Other treatment systems can also involve groundwater capture and upgradient reinjection. (See related discussion of in-situ treatment in Table B.1.)
Chemical		
Chemical injection	Hydrolysis, redox reactions (including ozonation and chlorination), dechlorination, chelation, neutralization, and precipitation	As described for chemical addition for surface water in situ (Table B.2), except that enhanced mixing by mechanical means is not an option.
Contact reaction system	Permeable treatment beds using pumps or French drain systems	Permeable treatment beds can reduce the toxicity, mobility, and volume of contaminated groundwater and mitigate potential exposures, biouptake, and migration by altering the contaminant source. This process is used in conjunction with collection (e.g., by pumps or drains). Bed media can range from crushed limestone and activated carbon to glauconitic green sands and synthetic ion-exchange resins. Implementation of this process is constrained by site-specific hydrogeological conditions.
Biological		
Bioreclamation	Nutrient/microbial injection	As described for surface water, except that mechanical mixing is not an option.

TABLE B.3 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment following Removal		
Physical		
Nonthermal extraction	Density separation (centrifugation), flocculation, filtration, adsorption, osmosis, reverse osmosis/ultrafiltration, electrolysis, electrodialysis, and freeze crystallization	As described for surface water following removal (Table B.2).
Thermal extraction/ destruction	Stripping, vapor recompression/distillation, wet air oxidation, supercritical water oxidation, liquid-injection incineration, chlorinolysis, and solar evaporation	As described for surface water following removal (Table B.2).
Chemical		
Extraction	Solvent extraction	As described for surface water following removal (Table B.2).
Chemical addition	Hydrolysis, redox reactions (including ozonation and chlorination), dechlorination, chelation, neutralization, precipitation, and ion-exchange and adsorption beds, using a reactor vessel	As described for surface water following removal (Table B.2).
Biological		
Suspended growth biodegradation	Continuous-flow stirred tank reactor and plug flow reactor	As described for slurried soil, sludge, and sediment following removal (Table B.1).
	Surface impoundment	As described for surface water following removal (Table B.2), except that the process would not mimic original conditions.
Attached growth biodegradation	Reactor systems, trickling filters, land farming, spray irrigation, and overland flow	As described for surface water following removal (Table B.2).

TABLE B.3 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Short-Term Storage		
On-site or off-site facility	Engineered structure	Short-term storage, e.g., in retention ponds, can reduce the mobility of contaminated water and mitigate potential exposures, bioupiake, and migration by controlling the contaminant source. This option requires the engineering of a storage facility and would be implemented as an interim measure while a permanent remedy was being developed.
Disposal		
On-site	Reinjection; or discharge on land or to surface water	As described for surface water following removal (Table B.2).
Off-site	Reinjection; or discharge on land, to a publicly owned treatment works, or to surface water	As described for surface water following removal (Table B.2).

TABLE B.4 Potential Response Actions and Technologies for Structural Material, Process Chemicals, and Vegetation

General Response Action/ Potential Technology Type	Potential Process Option	Comments
No Action		
Not applicable	Not applicable	The no-action alternative is included to provide a baseline for comparison with action alternatives.
Institutional Control		
Access restrictions	Fences and guards	Access restrictions can mitigate exposures by limiting access and use.
Ownership and use or deed restrictions	Legal titles and deeds	Ownership and use or deed restrictions can mitigate exposures by limiting access and use.
Monitoring	Groundwater wells and air, surface water, and soil, sludge, and sediment samplers	Monitoring can provide data for assessing the potential for exposure.
In-Situ Containment		
Sealers	Surface sprays, sealer paints, and emulsion applications	These release controls can limit contaminant mobility and mitigate potential exposures, blouptake, and migration from structural material by controlling the contaminant source. The processes can be implemented with conventional equipment.
Removal		
Dismantlement and demolition	Grapplers, shears, and wrecking equipment (balls and cranes)	Dismantlement and demolition can remove a structure from its current location and can be implemented with conventional equipment.
Decontamination	Aggressive vacuuming, dry fabric and solvent wiping, foam and emulsion applications, steam and high-pressure water washing, and carbon dioxide pellet and abrasive grit blasting	Decontamination processes can reduce the toxicity, mobility, and volume of contaminated structural material (e.g., via transfer to the decontamination residuals, such as fabric wipes or grit) and mitigate potential exposures, blouptake, and migration by removing the contamination. They can be used to remove organic and inorganic compounds, including removable (i.e., nonfixed) radionuclides from structural surfaces. These processes can be implemented with conventional equipment. (Insofar as decontamination removes contaminants from a medium, it can be considered both "removal" and "treatment/pretreatment" and is therefore included in both discussions.)

TABLE B.4 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Removal (Cont.)		
Clearing and grubbing	Bulldozer and front-end loader	Clearing and grubbing can reduce the toxicity, mobility, and volume of contaminated vegetation at an affected area by removing the contaminant source. These processes can be implemented with conventional equipment.
Treatment/Pretreatment In Situ		
Physical		
Decontamination/extraction	Vacuuming, wiping, washing, and wet/dry abrasive blasting	As described for decontamination under removal.
Chemical		
Decontamination/extraction	Solvent washing and foam and emulsion applications	As described for decontamination under removal.
Treatment/Pretreatment following Removal		
Physical		
Volume reduction	In-drum compactors, impact crushers, grapplers, pulverizers, tumbling and hammer mills, shredders, and chippers	These processes can reduce the volume and size of structural material and vegetation, as well as containerized solids such as swipes from decontamination activities, and they can be implemented with conventional equipment.
Decontamination/extraction	Vacuuming, wiping, washing, and wet/dry abrasive blasting	As described for decontamination under removal, often with improved results due to increased accessibility.
Thermal treatment	Melting and thermal destruction in kilns, incinerators, furnaces, and melters	Thermal treatment processes can reduce the toxicity, mobility, and volume of structural material, process chemicals, and vegetation and can mitigate potential exposures, biouptake, and migration by altering the contaminant source. These processes can destroy organic compounds and can incorporate inorganic compounds in a solid residue. Although certain thermal processes have been used in industrial applications, their demonstration for structural material and process chemicals has been limited.

TABLE B.4 (Cont.)

General Response Action/ Potential Technology Type	Potential Process Option	Comments
Treatment/Pretreatment following Removal (Cont.)		
Chemical		
Decontamination/nonthermal extraction	Solvent washing, foam and emulsion applications, and chemical (e.g., acid) bath extraction in a vessel	These processes can reduce the toxicity, mobility, and volume of structural material, as described for decontamination under removal, often with improved results due to increased accessibility.
Chemical addition	Hydrolysis, redox reactions, neutralization, precipitation, and solidification	Chemical addition can reduce contaminant toxicity and mobility in process chemicals, but the total volume of material would increase, as described for chemical addition/detoxification for soil, sludge, and sediment (Table B.1).
Stabilization/solidification	Lime-based and Portland-cement-based pozzolanic reactions, and silicate and absorbent binding in a reactor vessel.	Stabilization/solidification can reduce contaminant toxicity and mobility in process chemicals and structural material, but the total volume of material would increase, as described for stabilization/solidification of soil, sludge, and sediment (Table B.1).
Biological		
Composting	Open and static windrows and reactor vessels	Composting can reduce the mobility and volume of vegetative material (e.g., wood chips) and the toxicity of certain contaminants, if present (e.g., organic compounds), as described for composting of soil, sludge, and sediment contaminated with organic compounds (Table B.1).
Short-Term Storage		
On-site or off-site facility	Land-based engineered structure	As described for short-term storage of soil, sludge, and sediment (Table B.1).
Disposal		
On-site or off-site	Land-based engineered structure, such as a sanitary landfill constructed of soil material, a cell constructed of both soil and synthetic material, or a concrete vault; or ocean disposal	As described for disposal of soil, sludge, and sediment (Table B.1).

B.2 REFERENCES (APPENDIX B)

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APPENDIX C:

AIR QUALITY MODELING AND ANALYSIS

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AIR QUALITY MODELING AND ANALYSIS

Under current conditions and in the absence of remedial action activities, the Weldon Spring site does not impact ambient air quality and the air pathway does not contribute to public health impacts. However, emissions would result from implementing cleanup activities at the site. The air pathway is considered the principal route by which members of the general public could be exposed to site contaminants during the implementation of remedial action activities currently being considered. Therefore, emissions and atmospheric dispersion of particulates have been estimated for these activities to evaluate air quality impacts and support the health assessment for the cleanup period.

The modeling and analysis used to assess air quality are presented in this appendix. The results of this analysis have been used in the health assessment presented in Appendix F, which addresses potential human exposures to particulates in the air and to particulates that could be deposited on the ground as a result of contaminant releases from the site. Information from the air quality and health assessments has been used to support the evaluation of short-term effectiveness for the final remedial action alternatives being considered for site cleanup (Chapter 6). These final alternatives include the no-action alternative and four action alternatives. Two of the final action alternatives involve on-site treatment by either chemical stabilization/solidification (Alternative 6a) or vitrification (Alternative 7a) and on-site disposal. The other two alternatives involve on-site vitrification and off-site disposal at one of two locations, the Envirocare facility in Utah (Alternative 7b) or the Hanford facility in Washington (Alternative 7c).

The locations and configurations of the temporary facilities and the types and sequencing of activities evaluated in this appendix are based on preliminary conceptual engineering information for the project. The following analyses address representative conditions and are expected to bound potential impacts that could result from releases during the cleanup period.

Implementing any one of the action alternatives would generate both contaminated and uncontaminated emissions. Activities that could result in contaminated releases include excavating contaminated soil and sediment, operating stockpiles for this excavated material (e.g., for transportation to treatment and disposal facilities), and operating the treatment and disposal facilities (e.g., during unloading and waste placement activities). To minimize these releases, activities would be conducted in a manner designed to protect human health and the environment, and engineering controls would be incorporated into the treatment facilities. For example, the raffinate pit sludge would be handled as a wet slurry to minimize releases of particulates and radon gas, and the sludge processing facility for the vitrification alternatives would be equipped with air pollution controls to remove particulates from the off-gas stream (Chapter 5). Conventional dust control measures would also be used to minimize releases (Section C.3.5).

Activities that could result in uncontaminated emissions include (1) excavating borrow material in the vicinity of the site; (2) backfilling and regrading excavated areas; (3) constructing the disposal cell — e.g., compacting subgrade material, constructing the side slopes, and emplacing the cover; (4) stockpiling various support materials, such as borrow soil; and (5) transporting materials on paved and unpaved roads on-site and in the vicinity of the site, including truck transport of borrow soil or treatment additives to the site (Alternative 6a or 7a) or truck transport of waste off-site (Alternative 7b or 7c). Conventional dust control measures would also be used to minimize these releases.

Excavation and treatment activities would occur on-site under Alternatives 6a, 7a, 7b, and 7c, and related impacts to air quality for these alternatives at the Weldon Spring site are evaluated in detail in this appendix. Disposal activities would occur at the Weldon Spring site for Alternatives 6a and 7a and at off-site locations for Alternatives 7b and 7c. Therefore, related impacts are addressed for the Weldon Spring site under Alternatives 6a and 7a and for the Envirocare and Hanford facilities under Alternatives 7b and 7c, respectively.

For a comparative analysis of the final action alternatives, it was assumed that disposal activities such as constructing and operating the facility at the off-site locations would generally be similar to those activities evaluated for on-site disposal. This assumption is considered reasonable on the basis that similar, standard engineering methods and controls would probably be used for these activities regardless of the location. Such an assumption was necessary because the decision-making process for the Weldon Spring site is currently in the conceptual stage so the specific nature and scheduling of such activities for the off-site locations (if Alternative 7b or 7c were selected) have not yet been determined. Thus, potential impacts to air quality at the Envirocare and Hanford facilities associated with disposal of waste from the Weldon Spring site have been evaluated with screening-level calculations for comparison.

The methodology used to model air quality is described in Section C.1. The specific models are discussed in Section C.1.1, and the assumptions and model inputs are identified in Section C.1.2. The results of this modeling for the remedial action period are compared with ambient air quality standards in Section C.1.3, and the potential effectiveness of emission controls is discussed. Additional information on the analysis of meteorological data used to model atmospheric diffusion and transport for the Weldon Spring site is presented in Section C.2. Both annual average and 24-hour particulate emissions were estimated in this analysis to assess potential air quality impacts of fugitive dust and to compare predicted concentrations with the ambient standards. Emission inventories were estimated for each potential source area on-site and for affected areas off-site, and the results are presented in Section C.3. The exhaust emissions from heavy equipment used for cleanup operations are expected to be relatively low, so air quality impacts from these emissions were calculated for a worst-case situation.

C.1 METHODOLOGY FOR MODELING AIR QUALITY IMPACTS

The methodology used to assess air quality and potential health impacts was tailored to reflect the complexity of the cleanup activities being considered for the Weldon Spring site. This project-specific approach addressed the following factors:

- Source areas are widely scattered over the site, with varying levels of chemical and radioactive contamination.
- Both contaminated and uncontaminated emissions are relevant because the modeling results provide important input to both the air quality assessment and the health risk assessment.
- Cleanup activities for the various source areas are conceptually scheduled to occur at different times, ranging from a few days to a few years over the remedial action period.

This methodology involved the following tasks:

- The locations of emission sources were identified, and categories of specific activities were defined for each area;
- Specific receptor locations were identified for evaluation, including a network of perimeter locations and various nearby locations currently occupied by human receptors;
- Uncontrolled emission rates were calculated using emission factors provided by the U.S. Environmental Protection Agency (EPA 1985-1988, hereafter referred to as AP-42; EPA 1989a), and controlled emission rates were calculated using the efficiencies of control technologies provided by the EPA (1978, 1988, 1989a);
- Matrixes of 24-hour concentrations were constructed by source area for the various receptor locations by modeling particulate diffusion and transport with a unit emission factor;
- Both 24-hour maximum and annual average airborne particulate concentrations were calculated for each receptor location by multiplying the emission source strength at each area by the corresponding entry in the concentration matrix, considering the projected sequence of cleanup activities;
- Airborne concentrations of total particulates estimated for site perimeter locations were compared with ambient air quality standards to determine compliance;

- Concentrations of airborne contaminants and concentrations of contaminated particulates deposited at the current human receptor locations were calculated, the latter by including a component to model particulate deposition; and

- Concentrations of both airborne and deposited particulates from contaminated sources for each of these locations were tabulated, to use as input to the health assessment for the remedial action period.

C.1.1 Air Quality Models

Two air quality models recommended by the EPA (1986) were selected for assessing potential impacts from cleanup activities at the Weldon Spring site. The first — the Industrial Source Complex (ISC) model — is a steady-state Gaussian plume dispersion model and is the default dispersion model for air pathway analyses at Superfund sites (EPA 1989b). This model can be used to assess impacts associated with a wide variety of sources at an industrial complex, which describes the chemical plant. Accordingly, the model is well suited to evaluating airborne particulate concentrations that could result from the different types of emission sources distributed across the site. In addition, the model can account for particulate settling and dry deposition. Therefore, it was also used to calculate the deposition of contaminated particulates at various receptor locations to estimate potential health effects associated with releases of contaminated material that could occur during the cleanup period (Appendix F).

The ISC model is limited in its effectiveness for considering the effects of uneven terrain, and its application is restricted to areas of simple and flat terrain. The area adjacent to the site is in fact relatively flat and wooded. Although the Missouri River valley is located about 2.2 km (1.4 mi) from the site boundary, nonbuoyant fugitive dust from sources near the ground level (which describes the site sources) would only impact the area very close to the release. Therefore, the site terrain can be appropriately classified as simple, and the model limitation does not impact the analysis.

The ISC model includes two forms: the Industrial Source Complex, Short Term model (ISCST Version 88348; EPA 1987b, 1987c) and the Industrial Source Complex, Long Term model (ISCLT Version 90010; EPA 1987b, 1987c). Typically, the ISCST model is used to estimate 24-hour average particulate concentrations and the ISCLT model is used to estimate annual average concentrations. However, the ISCLT model was determined to be inappropriate for the current analysis because of the nature and scheduling of projected cleanup activities for the Weldon Spring site. The long-term model was designed to address continuous emissions, but site cleanup activities are expected to occur at various times during the remedial action period, sometimes lasting only a few days or weeks. For this reason, the ISCST model was determined to be more appropriate for estimating annual average particulate concentrations, and it was selected for calculating both the 24-hour and annual average particulate concentrations (airborne and deposited) associated with emissions from the various point, volume, and area sources at the Weldon Spring site (Section C.1.2.1).

The second model used to assess air quality impacts for the site is the third-generation California Line Dispersion model (CALINE3; Benson 1979). This model, which is also a steady-state Gaussian plume dispersion model, was originally developed to estimate the concentrations of nonreactive pollutants from highway traffic. The model contains an algorithm for predicting concentrations resulting from transportation activities. Therefore, it is considered appropriate for evaluating emissions associated with line sources, which describe the various haul routes that would be traveled to support cleanup activities. These routes would be used extensively both on-site and off-site (Section C.1.2.1), e.g., to move contaminated soil from source areas to staging or treatment areas on-site and to bring construction material or treatment additives to the site from off-site suppliers.

Another option would have been to evaluate a line source with the ISCST model using a simulation approach. That is, the line source could be divided into a number of elements of equal length and width to create multiple sources. These individual elements could be evaluated separately and the results summed to represent the entire source. However, this simulation approach would be inefficient for the current analysis because the total length of haul routes being considered extends to about 5 km (3 mi), so more than 300 individual volume sources would have to be modeled. The CALINE3 model was selected as the most appropriate model for evaluating air quality impacts associated with haul traffic during the remedial action period because it was designed specifically to address transportation activities.

C.1.2 Assumptions and Model Inputs

C.1.2.1 Emission Source Data

A potential emission source can be characterized by its type (i.e., point, volume, area, or line source), the nature of expected activities at that source, and the size of the area disturbed (in the case of an area source). A total of 1 point source, 3 volume sources, 21 area sources, and 29 line sources were evaluated for the Weldon Spring site. These sources are listed in Table C.1 and depicted in Figure C.1; related source emissions for the period from 1993 to 2000 are presented in Section C.3. Enclosed facilities, such as the sludge processing facility and the volume reduction facility, were modeled as volume sources. Potential emissions from these facilities include those associated with loading, unloading, feeding, mixing, and volume reduction operations. The stack emission from the vitrification facility was modeled as a point source. All emissions associated with the sludge processing facility other than the stack emission for the vitrification analysis were modeled as a volume source. The other discrete source areas and the haul routes at the site were modeled as area and line sources, respectively.

For this analysis, the volume and area sources were defined by a center point. It was assumed that emissions from the stack of the vitrification facility, which was modeled as a point source, were released from a 30-m (100-ft) stack with an internal diameter of 1.2 m (4 ft) at an exit velocity of 3.2 m/s (10 ft/s) and an exit temperature of 380°K (220°F) (MK-Ferguson

TABLE C.1 Sources Evaluated in the Air Pathway Analysis

Number	Type	Description[a]
S1	Area	Material staging area
S2	Volume	Volume reduction facility
S3	Volume	Sludge processing facility (CSS and VIT)[b]
S4	Point	Sludge processing facility (VIT)[b]
S5	Area	Disposal cell and buildings, Phase 1
S6	Area	Disposal cell and buildings, Phase 2
S7	Area	Disposal cell and buildings, Phase 3, and coal pile
S8	Area	Raffinate pits 1 and 2
S9	Area	Raffinate pit 3
S10	Area	Raffinate pit 4 (north)
S11	Area	Raffinate pit 4 (south)
S12	Area	Spoils pile
S13	Area	Ash Pond
S14	Area	Frog Pond
S15	Area	North Dump, mulch pile
S16	Area	South Dump
S17	Area	Material (soil) staging area (south)
S18	Area	Temporary storage area (north)
S19	Area	Temporary storage area (south)
S20	Area	Construction material staging area (east)
S21	Area	Construction material staging area (west)
S22	Volume	Water treatment plant[c]
S23	Area	Busch Lake 34
S24	Area	Busch Lake 35
S25	Area	Busch Lake 36
L1-L27	Line	Haul road segments on-site
L28-L29	Line	Haul road segments between the three off-site lakes and the site

[a] Sources at which activities would take place over large areas — such as the disposal cell, temporary storage area, construction material staging area, and raffinate pit 4 — were subdivided into two or three areas for air quality modeling. See Figure C.1 for locations of all source areas except S23, S24, S25, L28, and L29; see Figure C.2 for locations of S23, S24, and S25.

[b] The notation addresses the type of treatment that would be conducted at the facility, as determined by the alternative: CSS = chemical stabilization/solidification; VIT = vitrification. Stack emissions were evaluated only for the vitrification facility because they are not relevant for the CSS facility.

[c] The water treatment plant is included in this table because facility closure was addressed in this analysis; impacts related to construction and operation have been addressed separately (MacDonell et al. 1990).

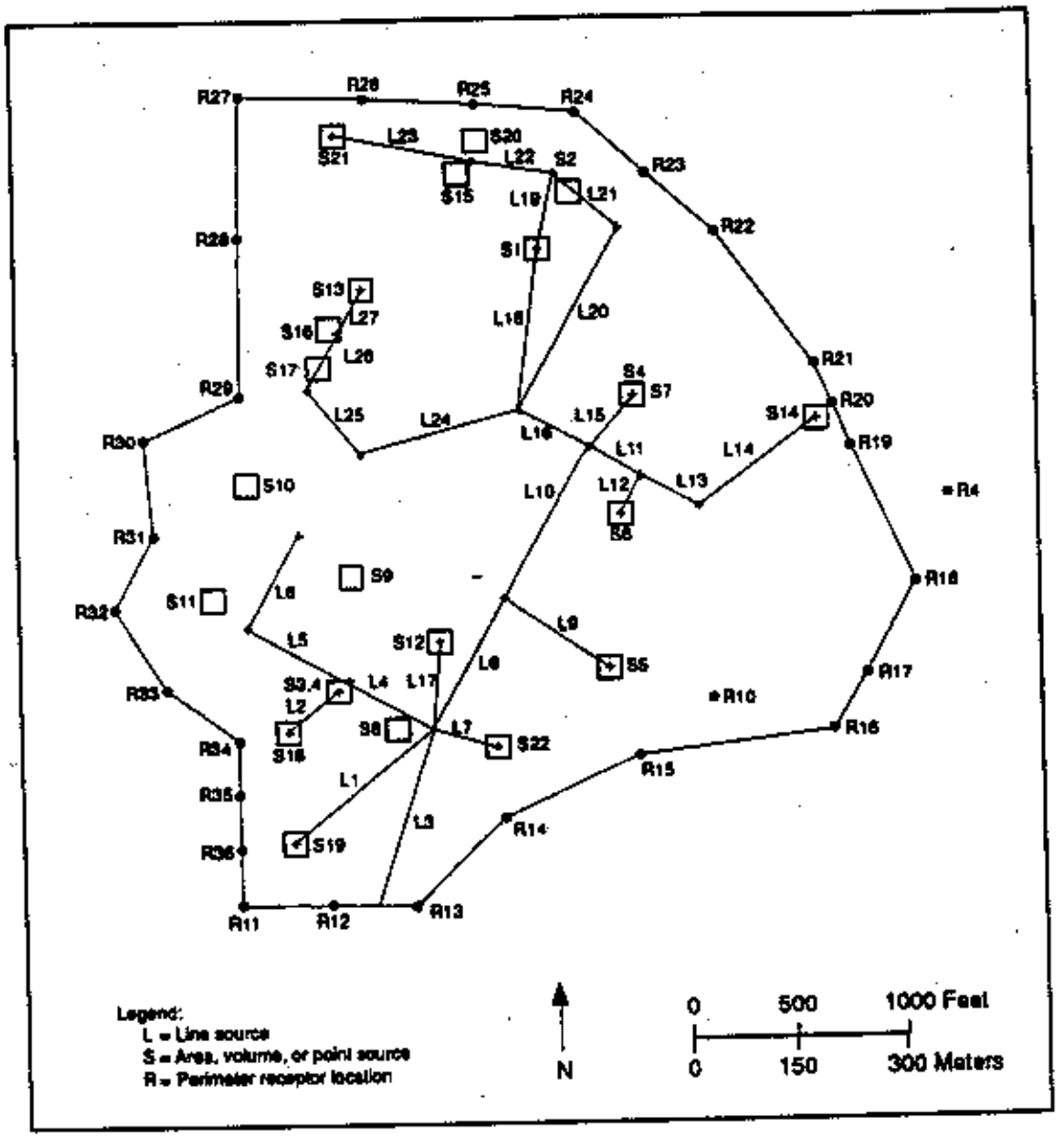

FIGURE C.1 Locations of the Line, Area, Volume, and Point Sources and Perimeter Receptor Locations Evaluated for the Weldon Spring Site

Company and Jacobs Engineering Group 1992). Other facilities, such as the volume reduction facility, were modeled as volume sources, assuming an area of 0.1 ha (0.25 acre) and a height of 10 m (33 ft).

It was also assumed that about 0.1 ha (0.25 acre) would be disturbed at each emission location during any 1-hour period, on the basis of the smallest area estimated to accommodate the equipment necessary for activities such as excavation and loading. This assumption is conservative, as indicated by model calculations that addressed the effect on related emissions of increasing the size of the area disturbed. Relatively large areas were represented by two or three "center" points; such areas are the disposal cell, the temporary storage area (TSA), the

construction material staging areas, and raffinate pit 4. Links — which are defined as straight segments of roadway having a constant width, height, traffic volume, and vehicle emission factor — were used to model the haul routes. The projected haul routes have several curved alignments that were approximated as straight lines for modeling purposes (see Figure C.1).

C.1.2.2 Meteorological Data

Representative meteorological data are important input to the dispersion model, and site-specific data are obviously preferred (EPA 1987a). Surface meteorological data were collected on-site from 1983 to 1985; the 1985 data were selected as the most representative for this air quality analysis (see Section C.2 and Lazaro [1989]). These meteorological data include hourly wind speed, wind direction, ambient temperature, and wind fluctuation in the horizontal direction. Atmospheric stability classes were determined from the latter using EPA methodology (EPA 1987a). Mixing heights were estimated from upper-air meteorological measurements taken twice daily in 1985 at a station in Salem, Illinois, located about 110 km (70 mi) east of St. Louis; these data were used to interpolate expected hourly mixing heights at the site. The meteorological data used in this analysis and a comparison of their statistical summaries with those for nearby weather stations are discussed in detail in Section C.2. (The collection of on-site meteorological data has recently been renewed, and the results will be incorporated into monitoring and testing activities for airborne contaminants during the cleanup period.)

C.1.2.3 Receptor Data

Thirty-six receptor locations were evaluated for this analysis. Ten of these represent locations currently occupied by human receptors, and the remaining 26 represent hypothetical receptor locations around the site perimeter (Figure C.1). Nine of the currently occupied locations are off-site, and the tenth is the on-site project office building (Figure C.2). The off-site locations are Francis Howell High School (student and janitor), a daycare facility (formerly the Weldon Spring Elementary School), the state highway maintenance facility, the guard house at the Army Reserve Training Area, the headquarters at the Busch Wildlife Area, and the closest three residences. Potential health impacts at these receptor locations are evaluated in Appendix F. Most emissions from the site are considered ground-level or near-ground-level, nonbuoyant releases. Maximum particulate concentrations would occur in close proximity to the emission sources. Calculations indicated that the maximum 24-hour and annual average concentrations resulting from stack emissions for the vitrification facility would occur near the northern site boundary. Therefore, the network of perimeter locations that had been identified for evaluation was considered adequate and no new receptor locations were added for this analysis. Estimated particulate concentrations at the 36 receptor locations resulting from remedial action activities are given in Section C.1.3.

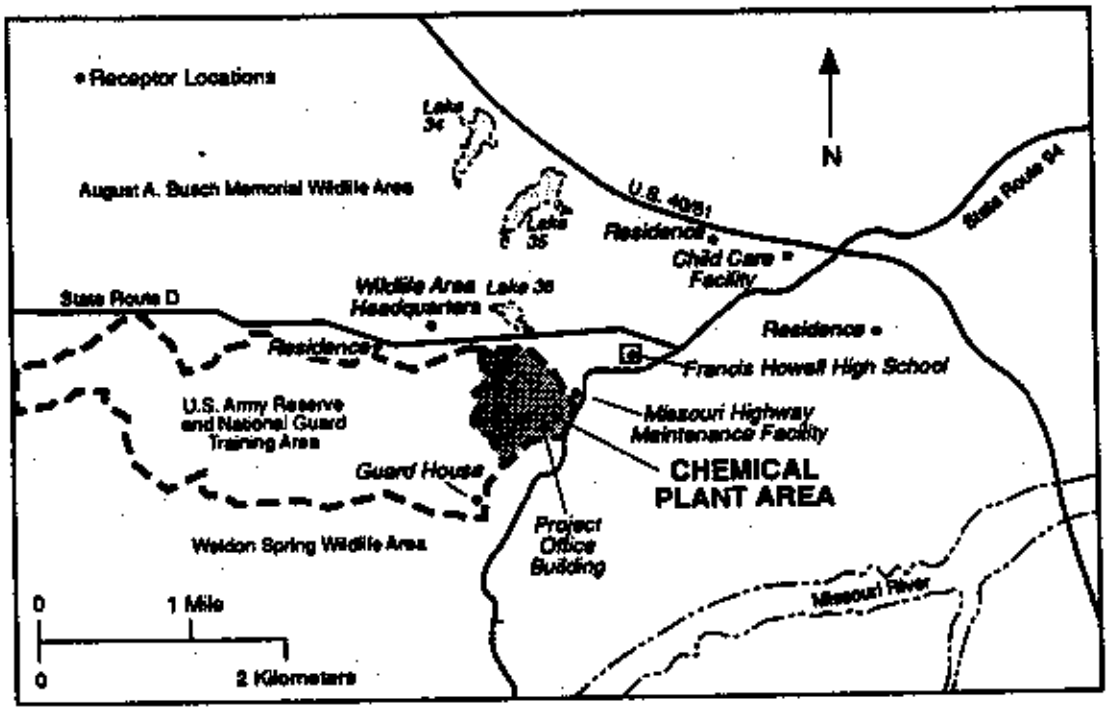

FIGURE C.2 Locations of Potential Current Receptors

C.1.3 Model Calculations and Comparison to Ambient Air Quality Standards

Ambient air quality in areas accessible to the general public is regulated by both state and federal standards. Missouri ambient air quality standards are the same as the National Ambient Air Quality Standards (Appendix G, Table G.2). These standards address six pollutants: sulfur oxides (as sulfur dioxide), carbon monoxide, ozone, nitrogen dioxide, lead, and particulates as PM-10 (i.e., particles with an aerodynamic diameter of ≤10 μm).

The annual ambient air quality standard for PM-10 is 50 $\mu g/m^3$ as the arithmetic mean. Compliance with this standard is determined on the basis of measured daily concentrations over 3 years or predicted daily concentrations for 1 year. The 24-hour standard for PM-10 is 150 $\mu g/m^3$, with not more than three expected exceedances permitted in any 3 consecutive years. To compare the model predictions with these values for both the 24-hour and annual cases, the predicted value at each receptor location was added to a background concentration of 24 $\mu g/m^3$. This background concentration represents an estimated PM-10 concentration for the rural St. Louis area, as determined from measurements taken during the regional air pollution study conducted in the 1970s (EPA 1980). Model-predicted particulate concentrations that could result from cleanup activities, stockpile operations, borrow material activities, and nearby road traffic are presented in Sections C.1.3.1 through C.1.3.4. Concentrations of air pollutants that could result from operating heavy equipment on-site (as represented by front-end loader and bulldozer activities) are discussed in Section C.1.3.5.

Airborne particulate concentrations that could result from remedial action activities for the Weldon Spring site were estimated for each final action alternative. Model predictions for Alternatives 6a and 7a are presented in the following discussion. Potential impacts to air quality at the Weldon Spring site from excavation and on-site treatment under Alternative 7b or 7c would be similar to those presented for Alternative 7a.

Particulate concentrations estimated for the Weldon Spring site from all sources combined (both contaminated and uncontaminated) would be lower for Alternatives 7b and 7c than those presented for Alternative 7a because of total emissions associated with the disposal facility. The initial construction and subsequent cover emplacement for a disposal cell would result in substantial releases of uncontaminated dust. If Alternative 7b or 7c were selected, the disposal facility would be constructed, operated, and closed at the Envirocare or Hanford facility, respectively, so related emissions would occur at those locations rather than at the Weldon Spring site. Potential impacts to air quality at these off-site facilities from disposal activities associated with waste from the Weldon Spring site were estimated using screening-level calculations.

To support the prediction of airborne particulate concentrations for Alternatives 6a and 7a, PM-10 emission inventories were developed for remedial action activities at the Weldon Spring site using conceptual cleanup considerations and relevant engineering information (Section C.3). These inventories consider both (1) contaminated material, e.g., for activities such as excavation, treatment, and waste placement, and (2) uncontaminated material, e.g., for activities such as cell construction, backfilling, regrading, and truck transport. Conventional dust control measures that would likely be used during these activities are also addressed. Estimated particulate concentrations associated with each of the major activities are discussed in Sections C.1.3.1 through C.1.3.5.

C.1.3.1 Cleanup Activities

Current conceptual cleanup plans for the Weldon Spring site indicate that both contaminated and uncontaminated material would be handled from 1993 through 1999, whereas only uncontaminated material associated with activities such as backfilling, regrading, and revegetating the site would be handled in the year 2000. Annual and 24-hour particulate concentrations (as PM-10, above background*) that could result from site cleanup activities were predicted for each final remedial action alternative. These concentrations were estimated for the 10 human receptor locations and the 26 site perimeter locations for each year of the remedial action period.

The estimated annual average concentrations of contaminated airborne particulates were also averaged over the cleanup period to provide a general indication of potential human exposures for the specific receptors evaluated. The average concentration for this period was

*Unless otherwise noted, all PM-10 concentrations reported in this appendix exclude the contribution from background. To estimate total PM-10 concentrations for the Weldon Spring site, the background concentration of 24 $\mu g/m^3$ for the rural St. Louis area should be added to the estimated values.

determined by summing the predictions for each year during which contaminated emissions would occur (1993-1999) and then dividing by the total number of years (7). This estimated annual average for the exposure period was used to assess potential health impacts (Appendix F).

The annual average concentrations of contaminated particulates that could be deposited at the current human receptor locations were also estimated for the health assessment; these estimates were calculated with the same models and assumptions used to calculate the estimated airborne contaminant concentrations at these locations, with one exception. For estimating particulate deposition, the effects of gravitational settling and dry deposition were taken into account; for estimating maximum airborne concentrations, the particulates were conservatively assumed to remain in the air. Although this approach results in higher estimated PM-10 concentrations at receptor locations and overpredicts inhalation exposures, it is expected to provide conservative estimates of potential impacts from airborne releases.

The following particle size distribution was assumed for the deposition calculation: 20% (by weight) of the contaminated particulates are ≤10 μm in diameter, 65% are 10 to 30 μm, 10% are 30 to 50 μm, and 5% are 50 to 100 μm. This distribution was determined from two factors. The first is the relationship between emission factors for PM-10 and total suspended particulates provided by the EPA for various activities (EPA 1985-1988, 1988, 1989a). The second factor is the particle size distribution determined for contaminated soil and sludge at the Weldon Spring site (MK-Environmental Services 1990). The particle density was assumed to be 2.7 g/m^3 (Grozescu 1991); other parameters used for the deposition calculations, such as the settling velocity and reflection coefficient, were determined from EPA recommendations (EPA 1987b).

Alternative 6a. The annual average and 24-hour particulate concentrations predicted for the current receptor locations under Alternative 6a are shown in Table C.2. Although the main gate was evaluated as a perimeter location, it is tabulated separately because of its likely occupancy (e.g., by a security guard) compared with the very low likelihood that any of the other perimeter locations would be occupied for any appreciable length of time during the cleanup period.

For the annual average estimates, the maximum particulate concentration predicted for a perimeter location from cleanup activities is 8.5 $\mu g/m^3$ for the worst year (1998) and 5.5 $\mu g/m^3$ averaged over the entire remedial action period (1993-2000). The highest concentrations estimated for the worst year would occur at the perimeter location near the north gate. The major contributors are uncontaminated emissions from road traffic (42%), contaminated emissions from the mulch pile (25%), and uncontaminated emissions from the construction material staging area (17%). Concentrations would be highest at this location because activities are expected to occur close to the northern site boundary and the predominant wind direction is from the south.

TABLE C.2 Estimated Annual and 24-Hour Average PM-10 Concentrations at the Weldon Spring Site for Alternative 6a, Chemical Stabilization/Solidification[a]

	Receptors	Estimated Concentration[b] ($\mu g/m^3$)				
		Annual Average		Highest 24-Hour Average		
		Maximum	Cleanup Period[c]	First	Second	Third
A	Nearby resident (janitor at Francis Howell High School)	0.3 (1995)	0.2	7.0 (1998)	7.0 (1996)	6.4 (1996)
B	Nearby resident (Department of Conservation employee)	0.3 (1995)	0.2	15 (1998)	11 (1997)	11 (1997)
C	Nearby resident (adjacent to U.S. Route 40/61)	0.1 (1998)	0.1	3.8 (1998)	3.5 (1996)	3.1 (1997)
D	Nearby resident (Weldon Spring Heights)	0.04 (1998)	0.03	2.1 (1998)	1.5 (1995)	1.4 (1998)
E	Student (Francis Howell High School)	0.3 (1995)	0.2	7.7 (1996)	7.6 (1997)	7.5 (1998)
F	Child (daycare facility)[d]	0.1 (1995)	0.1	2.5 (1997)	2.1 (1998)	2.1 (1997)
G	Worker (highway maintenance facility)	1.1 (1995)	0.7	24 (1998)	23 (1997)	22 (1995)
H	Worker (Army site representative)	0.8 (1995)	0.5	47 (1997)	42 (1995)	39 (1998)
I	Worker (Busch Wildlife Area headquarters)	0.4 (1995)	0.2	13 (1997)	12 (1997)	11 (1998)
J	Worker (on-site office building)	4.2 (1995)	2.0	100 (1997)	88 (1996)	88 (1995)
Hypothetical person at a perimeter post (main gate)[e]		1.5 (1995)	0.9	28 (1995)	28 (1997)	28 (1997)
Hypothetical person at site boundary[f]		8.5 (1998)	5.5	280 (2000)	200 (2000)	170 (2000)

[a] Reported concentrations are associated with remedial action activities only; to estimate the total PM-10 concentration, the background concentration of 24 $\mu g/m^3$ should be added to the listed value (see text).

[b] The air quality standards for annual average and 24-hour PM-10 concentrations are 50 and 150 $\mu g/m^3$, respectively (these are both the National Ambient Air Quality Standards and the Missouri state standards). The year in which the highest concentration is predicted to occur is given in parentheses.

[c] An average concentration was also estimated for the period from 1993 through 2000 to indicate the general magnitude of air quality impacts over the remedial action period.

[d] Although the daycare facility was recently destroyed by fire, this receptor location was retained for this assessment to address the possibility that the facility might be rebuilt for a similar use.

[e] Although this was evaluated as a site perimeter location, it is presented separately to reflect the increased likelihood of actual occupancy (e.g., by a security guard) compared with the other perimeter locations.

[f] Estimated maximum annual and 24-hour average concentrations would occur at perimeter locations near the construction material staging area and the Frog Pond area, respectively.

The on-site office building is the receptor location closest to the emission sources associated with remedial action activities. The maximum annual average particulate concentration estimated for a receptor at this location is 4.2 $\mu g/m^3$ for the worst year (1995); the average concentration for the entire period is 2.0 $\mu g/m^3$. The highest concentrations estimatedfor the off-site receptor locations are less than 1.1 $\mu g/m^3$. Combined with the background concentration of 24 $\mu g/m^3$, all of these predicted values are considerably below the annual air quality standard of 50 $\mu g/m^3$ for PM-10.

The highest 24-hour average particulate concentration of 280 $\mu g/m^3$ is estimated to occur at the perimeter location near Frog Pond in the year 2000 as a result of site backfill operations with uncontaminated material. The highest 24-hour average concentration predicted for the period during which contaminated material would be handled (1993 to 1999) is 170 $\mu g/m^3$ at the perimeter location near the north gate. The major contributors to this estimate are the handling of contaminated material from the mulch pile (42%) and the handling of uncontaminated material from the construction material staging area (31%).

The highest 24-hour average particulate concentrations predicted for the on-site office building are 100 $\mu g/m^3$ from both uncontaminated and contaminated sources and 50 $\mu g/m^3$ from contaminated sources only. The highest 24-hour concentrations predicted for the nine off-site receptor locations, including background, are considerably below the 24-hour air quality standard (Table C.2).

The methodology used for this analysis cannot accurately predict a worst-case concentration associated with activities near the site perimeter because it was assumed that the emission sources are represented by the center points of disturbed areas (Section C.1.2.1). High concentrations could occur at perimeter locations during operations near the site boundary. For example, concentrations at the adjacent perimeter locations would be expected to be high during the backfilling of raffinate pit 4. Therefore, additional dust control measures such as water sprays would probably be needed during such activities. Other control measures that could be applied to limit particulate emissions include reducing daily processing rates and considering meteorological conditions such as wind speed and direction when scheduling certain activities.

In general, particulate concentrations that could result from site cleanup activities are expected to be relatively low, except for high 24-hour average concentrations that might occur at the perimeter when activities were being conducted near the site boundary. These concentrations are not expected to significantly impact human health or the environment because (1) they would be distributed over a wide area; (2) most of the activities near the site boundary would involve uncontaminated material and the major source areas that would contribute significantly to contaminated emissions are located at some distance from the perimeter; (3) much of the contaminated material would be handled in a wet condition; and (4) only one shift would be operating during the day, which is when atmospheric dispersion conditions are such that air pollutants are least likely to accumulate.

Emissions from contaminated sources were also evaluated with atmospheric dispersion modeling to support the health assessment for Alternative 6a. Model-predicted annual average concentrations of contaminated airborne particulates at the current receptor locations are shown

in Table C.3, and results of the deposition calculations are shown in Table C.4. The human health assessment is presented in Appendix F.

Alternative 7a. The annual average and 24-hour particulate concentrations predicted for the current receptor locations under Alternative 7a are shown in Table C.5. Whereas the final waste volume would increase under chemical stabilization/solidification, vitrification would decrease the final volume. Therefore, the vitrification alternative would require a smaller disposal facility than the chemical treatment alternative. Because constructing and covering a disposal cell can generate a considerable amount of fugitive dust, reduced emissions are associated with the smaller facility. Thus, total particulate concentrations (i.e., from contaminated and uncontaminated sources combined) would generally be slightly lower for Alternative 7a than Alternative 6a. (Some exceptions do exist, depending on the source-receptor relationship and the differences in estimated work schedules.)

The highest annual average particulate concentration predicted to occur at any location during the remedial action period is 6.5 $\mu g/m^3$ for 1997; averaged over the entire period, the highest concentration is 4.6 $\mu g/m^3$. The concentrations for the worst year would occur at the perimeter location near the north gate, and they are primarily associated with uncontaminated emissions from road traffic (45%) and the construction material staging area (34%). Particulate concentrations would be highest at this location because these activities are expected to occur close to the northern site boundary and the predominant wind direction is from the south. The on-site office building is the receptor location closest to the emission sources associated with site cleanup activities. The maximum concentration estimated for a receptor at this location is 2.7 $\mu g/m^3$ for the worst year (1995); the concentration averaged over the entire period is 1.9 $\mu g/m^3$. The highest concentrations at the off-site receptor locations are estimated to be less than 0.8 $\mu g/m^3$. Combined with the background concentration of 24 $\mu g/m^3$, all these predicted values are considerably below the annual air quality standard for PM-10.

The highest 24-hour PM-10 concentration at the site perimeter is estimated to be 280 $\mu g/m^3$ at the location near Frog Pond; this concentration would result from backfill operations with uncontaminated material. The highest 24-hour concentration predicted for the period during which contaminated material would be handled (1993 through 1999), is 150 $\mu g/m^3$, which would occur at the perimeter location closest to the on-site office building. This level would result primarily from operations at the disposal cell (70%) and road traffic (21%). The highest 24-hour particulate concentrations predicted for the on-site office building are 93 $\mu g/m^3$ from both uncontaminated and contaminated sources and 50 $\mu g/m^3$ from contaminated sources only. The highest 24-hour concentrations predicted for the nine off-site receptors, including the background concentration, are considerably below the 24-hour air quality standard (Table C.5).

Alternative 7a involves an additional source of contaminated emissions not associated with Alternative 6a, i.e., emissions from the vitrification stack. The vitrification facility is expected to operate 24 hours per day, 365 days per year. However, no significant air quality impacts are expected to result from these emissions because the facility would be equipped with

TABLE C.3 Estimated Annual Average Concentrations of Airborne Particulates at Potential Receptor Locations from Contaminated Sources for Alternative 6a, Chemical Stabilization/ Solidification, and Alternative 7a, Vitrification

Treatment Method/ Year	Estimated Annual Average Airborne PM-10 Concentrations at Potential Receptor Locations[a] ($\mu g/m^3$)									
	A	B	C	D	E	F	G	H	I	J
Chemical Stabilization/ Solidification										
1993	0.013	0.007	0.004	0.002	0.014	0.002	0.072	0.013	0.010	0.240
1994	0.007	0.005	0.001	0.001	0.008	0.001	0.050	0.008	0.007	0.117
1995	0.024	0.017	0.006	0.004	0.028	0.006	0.095	0.064	0.018	0.675
1996	0.022	0.015	0.005	0.003	0.028	0.005	0.116	0.053	0.020	0.530
1997	0.034	0.025	0.013	0.005	0.044	0.011	0.180	0.099	0.049	0.574
1998	0.044	0.044	0.017	0.008	0.051	0.014	0.189	0.129	0.071	0.232
1999	0.007	0.003	0.003	0.001	0.009	0.003	0.041	0.023	0.004	0.046
Average[b]	0.022	0.017	0.007	0.003	0.026	0.006	0.106	0.056	0.026	0.345
Vitrification										
1993	0.008	0.006	0.003	0.001	0.008	0.002	0.048	0.012	0.010	0.197
1994	0.007	0.007	0.004	0.001	0.009	0.003	0.044	0.021	0.011	0.123
1995	0.025	0.018	0.006	0.004	0.028	0.006	0.105	0.087	0.019	0.733
1996	0.013	0.010	0.004	0.002	0.015	0.003	0.071	0.047	0.014	0.376
1997	0.043	0.046	0.013	0.006	0.053	0.012	0.187	0.126	0.078	0.850
1998	0.044	0.047	0.015	0.008	0.053	0.012	0.189	0.123	0.073	0.496
1999	0.012	0.008	0.003	0.002	0.014	0.003	0.072	0.026	0.007	0.181
Average[b]	0.022	0.020	0.007	0.003	0.026	0.006	0.102	0.063	0.030	0.422

[a] The potential receptors are described in Table C.2, and the locations are shown in Figure C.2.

[b] Averaged over the period from 1993 through 1999.

an extensive off-gas treatment system (Section 5.3.2) and this system would be optimized for maximum collection efficiency during the design phase of remedial action planning if Alternative 7a, 7b, or 7c were selected. Using the removal efficiencies estimated for this system as part of preliminary engineering considerations (MK-Ferguson Company and Jacobs Engineering Group 1992), stack emissions of criteria pollutants such as PM-10, carbon monoxide, and sulfur dioxide are expected to be negligible. The highest annual average concentration predicted for nitrogen dioxide, 10 $\mu g/m^3$ near the north gate, is only a small fraction of the national ambient air quality standard of 100 $\mu g/m^3$. As for Alternative 6a, potential air quality impacts associated with site cleanup activities would be relatively minor for Alternative 7a, provided that appropriate dust control measures were used for activities conducted adjacent to the site boundary.

TABLE C.4 Estimated Annual Concentrations of Particulates Deposited at Potential Receptor Locations from Contaminated Sources for Alternative 6a, Chemical Stabilization/Solidification, and Alternative 7a, Vitrification

Treatment Method/ Year	Estimated Annual Particulate Deposition at Potential Receptor Locations[a] (mg/kg soil)									
	A	B	C	D	E	F	G	H	I	J
Chemical Stabilization/ Solidification										
1993	0.22	0.14	0.08	0.05	0.22	0.06	0.71	0.31	0.11	2.64
1994	0.09	0.06	0.03	0.02	0.10	0.03	0.73	0.08	0.06	1.04
1995	0.52	0.35	0.20	0.10	0.60	0.20	1.45	0.99	0.33	9.12
1996	0.40	0.37	0.13	0.07	0.51	0.12	1.77	1.20	0.41	7.60
1997	0.52	0.54	0.46	0.22	0.61	0.38	2.01	1.88	0.59	7.07
1998	0.69	1.03	0.46	0.22	0.80	0.33	2.52	2.51	1.08	2.88
1999	0.09	0.07	0.07	0.04	0.11	0.04	0.53	0.38	0.08	0.50
Average[b]	0.36	0.37	0.20	0.10	0.42	0.17	1.39	1.05	0.38	4.41
Total[c]	2.53	2.56	1.43	0.73	2.96	1.17	9.72	7.35	2.67	30.85
Vitrification										
1993	0.15	0.16	0.09	0.07	0.14	0.08	0.51	0.29	0.12	2.21
1994	0.10	0.17	0.09	0.03	0.12	0.04	0.49	0.51	0.13	1.22
1995	0.44	0.43	0.20	0.11	0.51	0.19	1.54	1.81	0.45	10.06
1996	0.20	0.26	0.11	0.05	0.23	0.08	0.92	1.08	0.29	4.61
1997	0.63	1.04	0.38	0.22	0.76	0.34	2.20	3.86	0.97	11.30
1998	0.70	1.03	0.39	0.20	0.81	0.32	2.44	2.93	1.14	6.02
1999	0.18	0.17	0.09	0.05	0.21	0.07	0.93	0.45	0.16	2.36
Average[b]	0.34	0.46	0.19	0.11	0.40	0.16	1.29	1.56	0.47	5.40
Total[c]	2.40	3.25	1.34	0.74	2.78	1.12	9.04	10.94	3.26	37.79

[a] The potential receptors are described in Table C.2, and the locations are shown in Figure C.2. The deposited concentration as "mg/kg soil" was obtained by converting the unit "g/m^2" from the output of the deposition model to "mg/kg soil," assuming that the material is deposited to a depth of 1 cm in the soil and the density is 1.8 g/cm^3 (determined from soil data for the site).

[b] Averaged over the period from 1993 through 1999.

[c] Cumulative total deposition over the period from 1993 through 1999.

TABLE C.5 Estimated Annual and 24-Hour Average PM-10 Concentrations at the Weldon Spring Site for Alternative 7a, Vitrification[a]

Receptors	Estimated Concentration[b] ($\mu g/m^3$)				
	Annual Average		Highest 24-hour Average		
	Maximum	Cleanup Period[c]	First	Second	Third
A Nearby resident (janitor at Francis Howell High School)	0.2 (1997)	0.1	7.8 (1997)	6.8 (1997)	5.4 (1996)
B Nearby resident (Department of Conservation employee)	0.2 (1997)	0.1	10 (1998)	9.0 (1999)	8.8 (1996)
C Nearby resident (adjacent to U.S. Route 40/61)	0.1 (1997)	0.1	2.6 (1998)	2.5 (1997)	2.5 (1995)
D Nearby resident (Weldon Spring Heights)	0.03 (1998)	0.02	1.6 (1997)	1.4 (1998)	1.4 (1995)
E Student (Francis Howell High School)	0.2 (1997)	0.2	8.4 (1997)	8.2 (1997)	6.4 (1994)
F Child (daycare facility)[d]	0.05 (1999)	0.04	2.1 (1997)	2.0 (1996)	2.0 (1994)
G Worker (highway maintenance facility)	0.8 (1997)	0.6	25 (1996)	24 (2000)	23 (1997)
H Worker (Army site representative)	0.6 (1997)	0.5	39 (2000)	36 (1999)	30 (1994)
I Worker (Busch Wildlife Area headquarters)	0.3 (1997)	0.2	11 (1997)	10 (1996)	9.9 (1997)
J Worker (on-site office building)	2.7 (1995)	1.9	93 (1998)	86 (1995)	83 (1995)
Hypothetical person at a perimeter post (main gate)[e]	1.0 (1997)	0.7	28 (1995)	27 (1995)	26 (1996)
Hypothetical person at site boundary[f]	6.5 (1997)	4.6	280 (2000)	200 (2000)	170 (2000)

[a] Reported concentrations are associated with remedial action activities only; to estimate the total PM-10 concentration, the background concentration of 24 $\mu g/m^3$ should be added to the listed value (see text).

[b] The air quality standards for annual average and 24-hour average PM-10 concentrations are 50 and 150 $\mu g/m^3$, respectively (these are both the National Ambient Air Quality Standards and Missouri state standards). The year in which the highest concentration is predicted to occur is given in parentheses.

[c] An average concentration was also estimated for the period from 1993 through 2000 to indicate the general magnitude of air quality impacts over the remedial action period.

[d] Although the daycare facility was recently destroyed by fire, this receptor location was retained for this assessment to address the possibility that the facility might be rebuilt for a similar use.

[e] Although this was evaluated as a site perimeter location, it is presented separately to reflect the increased likelihood of actual occupancy (e.g., by a security guard) compared with the other perimeter locations.

[f] Estimated maximum annual and 24-hour average concentrations would occur at perimeter locations near the construction material staging area and the Frog Pond area, respectively.

Potential emissions from contaminated sources were also evaluated with atmospheric dispersion modeling to support the health assessment for Alternative 7a. Model-predicted concentrations of contaminated airborne particulates at the current receptor locations are shown in Table C.3, and results of the deposition calculations are shown in Table C.4. The human health assessment is presented in Appendix F.

Alternative 7b. Overall impacts to air quality at the Weldon Spring site would be much lower for Alternative 7b than Alternative 7a because emissions associated with the disposal cell (which are primarily uncontaminated) would occur at the Envirocare facility rather than on-site and the incremental contribution from nearby transport activities would be negligible. Material would be transported from the site in closed containers, so no measurable emissions would be expected from waste transport to the rail siding in Wentzville, Missouri, or from unloading and loading during transfer operations at the siding. Similarly, emissions are not expected to occur during transport to the Envirocare facility.

No detailed information is available for activities that would be conducted to construct and operate a cell at the 220-ha (540-acre) Envirocare facility if it were selected as the disposal location for the Weldon Spring waste. Therefore, to provide a very preliminary estimate of potential air quality impacts for a comparative analysis, a screening-level analysis was conducted in which simplifying assumptions for the disposal activities were combined with available site-specific data for factors such as surface features and meteorological conditions (U.S. Department of Energy [DOE] 1984; Envirocare of Utah 1991; EPA 1991). For Alternative 7b, the area of the cell required for the Weldon Spring waste, the nature of construction and operation activities, related emission factors, and dust control measures at the Envirocare facility were assumed to be similar to those evaluated for the Weldon Spring site under Alternative 7a. Potential air quality impacts were modeled using site-specific information and assuming that a 17-ha (42-acre) disposal cell would be constructed and operated over a 5-year period in the southwest area of the Envirocare site.

The PM-10 concentrations estimated from this screening-level analysis are 78 $\mu g/m^3$ and 8.5 $\mu g/m^3$ for the highest 24-hour and annual average, respectively, at the site boundary location closest to the disposal cell. For the potential receptor at the Envirocare site office, which is located in a north-central area of the site, the PM-10 concentrations are estimated to be 26 $\mu g/m^3$ and 1.7 $\mu g/m^3$ for the highest 24-hour and annual average, respectively. The nearest residential areas are currently located 40 km (25 mi) away from the site. Therefore, no measurable particulate concentrations are expected at off-site residences as a result of emissions from constructing and operating a disposal facility at the Envirocare site to manage the Weldon Spring waste.

On the basis of information currently available for the Envirocare site, the disposal facility could be located close to the site boundary. Therefore, when weather patterns were unfavorable or the workload was heavy, the 24-hour PM-10 concentration could be higher than those predicted in this screening-level analysis and might exceed the short-term air quality standard. In such situations, it is expected that additional dust control measures would be used.

Alternative 7c. Overall impacts to air quality at the Weldon Spring site under Alternative 7c would be much lower than those for Alternative 7a because emissions associated with the disposal cell would occur at the Hanford facility rather than on-site and the incremental contribution from transport activities would be negligible (as described for Alternative 7b). Emissions of contaminated material would be similar for these two alternatives.

No detailed information is available for activities that would be conducted to construct and operate a cell at the 1,500-ha (3,700-acre) Hanford Reservation if it were selected as the disposal location for the Weldon Spring waste. Therefore, to provide a very preliminary estimate of potential air quality impacts for a comparative analysis, a screening-level analysis was conducted in which simplifying assumptions for the disposal activities were combined with available site-specific data for factors such as surface features and meteorological conditions (DOE 1987, 1991; EPA 1991). For Alternative 7c, the area of the cell required for the Weldon Spring waste, the nature of construction and operation activities, related emissions, and dust control measures at the Hanford facility were assumed to be similar to those evaluated for the Weldon Spring site under Alternative 7a. Potential air quality impacts were modeled using site-specific information and assuming that a 17-ha (42-acre) cell would be constructed and operated over a 5-year period in the 200-West Area of the Hanford Reservation.

The PM-10 concentrations estimated from this screening-level analysis are 7.0 and 0.1 $\mu g/m^3$ for the highest 24-hour and annual average, respectively, at the potential receptor location closest to the disposal cell (on State Route 240, which runs through the Hanford Reservation). It was assumed that conventional dust control measures would be used during cell construction activities to minimize fugitive dust emissions (some of which might be contaminated as a result of previous site activities). These measures would be expected to limit potential worker impacts associated with constructing a facility for the Weldon Spring waste, and they would also limit the potential for particulate dispersion from the work area.

The Hanford Reservation is very large, and the disposal facility was assumed to be located in the 200-West Area, which is about 10 km (6 mi) from the site boundary (DOE 1987). Therefore, PM-10 concentrations at potential perimeter receptor locations as a result of disposal activities would be negligible. Similarly, no measurable particulate concentrations would be expected at any off-site resident location as a result of emissions from constructing and operating a disposal facility at the Hanford site to manage the Weldon Spring waste.

Comparative Analysis. Particulate emissions associated with excavation and treatment activities at the Weldon Spring site are expected to be somewhat similar for each of the four alternatives because the same material would be handled for each. Relative to ambient air quality standards, it is expected that PM-10 concentrations at the site perimeter could temporarily increase when certain dust-generating activities were conducted near the fence line, such as backfilling excavated areas with uncontaminated borrow soil. Therefore, during these activities, dust control efforts would be intensified to ensure compliance with ambient air quality standards. In fact, information from this air quality assessment will be used to focus the development of appropriate dust control strategies for the site during the detailed design stage for this remedial action.

Emissions associated with disposal activities would occur on-site under Alternatives 6a and 7a, whereas they would occur off-site under Alternatives 7b and 7c. Assuming for this comparative analysis that the disposal activities would generally be the same at each alternative site, related emissions for Alternatives 7b and 7c are expected to be somewhat similar to those indicated for Alternative 7a. It is also assumed that appropriate dust control measures would be used to control emissions so that air quality standards would be met at the off-site locations. For example, preliminary screening-level calculations indicate that particulate concentrations at the perimeter of the Envirocare site could potentially be elevated under certain meteorological conditions; additional dust control measures could be applied to reduce these levels in such cases.

For the two on-site disposal alternatives, both the total emissions (contaminated and uncontaminated) and the uncontaminated emissions would be higher for Alternative 6a (chemical stabilization/solidification) than for Alternative 7a (vitrification). This difference is primarily the result of fugitive dust associated with cell construction and with on-site transport of the higher volume of treated material. Uncontaminated emissions from activities such as constructing the foundation and cover of the disposal facility would be higher because more borrow soil and other construction material (e.g., sand and gravel) would be used to construct the larger facility for the chemically treated material.

Although the amount of contaminated material handled under each alternative would be similar, contaminated emissions are estimated to be slightly higher for Alternative 7a, primarily because of the increased handling of soil associated with both the initial preparation of the disposal cell area and waste placement into the operational facility. On average over the remedial action period, these concentrations are expected to be generally the same or somewhat higher for Alternative 7a (e.g., increased by 20%) compared with Alternative 6a. However, the relative relationships between the alternatives would vary from year to year, as indicated in Tables C.3 and C.4, because of differences in scheduling and sequencing of construction and operation activities and the prevailing meteorological conditions under which the various activities would be conducted.

Contaminated particulates would be released from the stack of the on-site vitrification facility under Alternatives 7a, 7b, and 7c, but no such releases are associated with treatment by chemical stabilization/solidification for Alternative 6a. Stack emissions would be very low compared with fugitive dust releases, e.g., those generated by excavating contaminated areas. Particulates released from the vitrification stack are not expected to contribute measurably to estimated concentrations of contaminated airborne and deposited particulates because the extensive engineering controls that would be incorporated into the off-gas treatment system (Section 5.3.2) are assumed to reduce stack emissions to nominal levels. Emissions from other treatment facilities, such as the volume reduction facility, would be similar for each of the four alternatives.

The nature of phased construction identified from conceptual engineering considerations for the disposal cell under Alternative 7a is a major reason for the increased levels of contaminated airborne and deposited particulates associated with this alternative. Compared with

Alternative 6a, the construction sequence for Alternative 7a would result in additional handling of soil from beneath the dismantled chemical plant buildings. Under Alternative 6a, each of the three phases of the combination disposal cell would be constructed in sequence. This would minimize the double handling of soil from the area proposed for the disposal cell because soil excavated to construct the second and third phases of the cell could be placed directly into the first phase of the operational facility. In contrast, both the first phase of the combination cell and the entire vitrification cell (which corresponds to the third phase of the combination cell) would be constructed at the same time under Alternative 7a. Therefore, the soil excavated to construct the vitrification cell would have to be transported to the material staging area (MSA) until the first portion of the operational facility became available, after which the soil would be transported back to the cell area for disposal.

An additional factor affecting estimated contaminant emissions for each alternative is the rate at which soil would be transported from the TSA to the treatment facility. This rate would be four times higher under Alternative 6a than under Alternative 7a (and Alternatives 7b and 7c) during 9 months of the year. In response, a larger front-end loader would be used at the TSA to support chemical treatment activities; this equipment would operate over a smaller number of transport cycles with relatively lower particulate emission rates per volume of soil handled. In addition, chemical treatment operations and related transport activities would cease during the winter months, whereas operations for the vitrification facility would continue year-round. As a result, particulate emissions from TSA activities would be higher under Alternative 7a.

Source-receptor relationships and meteorological conditions would also contribute to differences in the concentrations of airborne and deposited particulates from contaminated sources predicted for the two different treatment methods. On the basis of conceptual engineering considerations, treated and untreated material were assumed to be relatively evenly distributed between each of the three phases of the disposal cell under Alternative 6a, whereas no untreated material would be placed in the third phase (i.e., the vitrification cell) under Alternative 7a. This untreated material is the source of contaminated emissions associated with waste placement activities, and, under Alternative 7a, its volume would be higher in the two southern components of the disposal facility (which constitute the cell for material that would not be vitrified) compared with the same area (i.e., the first and second phases of the combination cell) under Alternative 6a (Chapter 5, Sections 5.2.3 and 5.3.3). Therefore, receptors located closest to this southern area of the disposal facility and in the direction of prevailing winds during the scheduled placement activities would be exposed to higher levels of contaminated particulates under Alternative 7a than under Alternative 6a.

For example, the concentration of contaminated particulates resulting from cell activities at the location of the on-site office worker would be higher under Alternative 7a than under Alternative 6a because a greater volume of untreated material would be handled nearby at the southern portions of the disposal facility. Similarly, the proximity of this receptor to the TSA would result in higher concentrations of contaminated particulates under Alternative 7a because of differences in emissions associated with soil transport activities at that area. In general, the estimated concentrations of contaminated particulates would be higher under Alternative 7a for

receptors located near the site, clockwise from the southeast to the northwest, because meteorological conditions at the site and the relative proximity to contaminated sources are expected to result in higher emissions. For the other receptor locations, the average concentrations of contaminated particulates over the exposure period would generally be the same or slightly higher under Alternative 6a.

C.1.3.2 On-Site Stockpile Operations

Contaminated material would be temporarily stockpiled at the TSA and the MSA after being removed from various source areas, pending the availability of the operational treatment facility and/or disposal cell. Clean material used to construct the disposal cell and to backfill excavated areas would be stockpiled at the construction material staging area within the MSA and at other locations near areas of specific backfill needs.

Both stockpiles and disturbed work areas would be subject to dust generation by wind erosion. The wind speeds measured at the site indicate that winds are probably not strong enough to cause significant erosion (Section C.2). Therefore, a screening model was used to calculate potential impacts from wind erosion rather than developing detailed emission inventories for these sources. Using the emission factor for wind erosion given in Section C.3 and assuming a 0.1-ha (0.25-acre) stockpile area and a dust control efficiency of 50%, the maximum annual and 24-hour PM-10 concentrations from wind erosion are predicted to be 4 and 110 $\mu g/m^3$, respectively, near the edge of the pile. These PM-10 concentrations decrease rapidly with distance from the source, e.g., 10% at 100 m (330 ft) and 0.2% at 1,000 m (3,300 ft). Although certain stockpiles are expected to be located near the site boundary, the impact of fugitive dust releases on potential off-site receptors is expected to be minor because wind speeds high enough to generate wind erosion would also mix the airborne particulates in a large air mass and thus would dilute the emissions, thereby offsetting the potential for impact from other possible on-site sources of fugitive dust.

Dust control methods that would be considered as part of detailed design activities include covering stockpiles with plastics or tarps. Spraying water and/or applying chemical dust suppressant, especially during dry seasons, could also augment the suppression of fugitive dust emissions from wind erosion. In addition, emissions could be reduced by hauling material such as construction supplies for direct use when it was needed, thereby limiting stockpiling.

C.1.3.3 Off-Site Borrow Operations

A 61-ha (150-acre) area located across from Francis Howell High School is considered a potential representative source of borrow soil that would be used for backfilling areas excavated on-site and for constructing a disposal facility. If this location were selected, current plans indicate that a dedicated haul route would be constructed along the south side of State Route 94 to provide access to the site.

Excavating and transporting this clean borrow material to the site could result in elevated levels of fugitive dust at nearby receptor locations. The highest annual and maximum 24-hour PM-10 concentrations at the high school, calculated by applying the rate currently estimated for borrow operations and assuming the same control measures as used on-site, are estimated to be 2.7 and 28 $\mu g/m^3$, respectively. These estimates were determined for a worst-case day; in general, releases would be much lower. The major contributor to these concentrations would be truck traffic on the unpaved haul route. Although winds from the south prevail and the haul route would run close to the high school, the borrow soil operations are expected to have only a minor impact on that receptor location because activities would occur during daytime hours when the meteorological conditions are most favorable. As needed, more stringent control measures could be applied, such as frequent water spraying, oiling, or paving the haul road; alternatively, an enclosed, elevated conveyor system could be constructed to transport the material across the highway.

C.1.3.4 Traffic on Nearby Public Roads

The highest 24-hour and annual average particulate concentrations for receptor locations from traffic on nearby paved public roads were predicted for both current conditions (using 1990 data) and conditions that would exist during the remedial action period (as represented by the worst year, 1995). Traffic volumes were estimated by extrapolating from historical traffic count trends for these roads (Horner & Shifrin 1991), and they reflect the projected increase in traffic associated with cleanup activities at the site. Fugitive dust emissions on State Route 94, State Route D, and a road to the Army property from Route 94 that runs along the southern boundary of the site were estimated using emission factors for vehicle traffic on a paved road (taken from Section 11.2.5 of AP-42). These traffic volumes and emission rates were then input to the CALINE3 model to assess the impact of road traffic on ambient air quality. Estimated PM-10 concentrations from traffic sources at perimeter and nearby receptor locations are presented in Table C.6. The increased concentrations result primarily from general traffic volume growth projected for the paved public roads, whereas only a small increment is expected from traffic associated with site activities. Estimated PM-10 concentrations at the main gate perimeter location are relatively high, with highest 24-hour concentrations of 28 and 34 $\mu g/m^3$ and annual average concentrations of 9.4 and 12 $\mu g/m^3$ for current and future conditions, respectively. However, because this location is between the areas of general site activities and Route 94, the impacts from site activities and traffic-related emissions from Route 94 are not expected to be additive. At Francis Howell High School, the most populated of the nearby receptor locations, impacts from estimated PM-10 concentrations are also expected to be minor, even when considering the potential contribution of fugitive dust from the nearby borrow area.

Comparing the levels estimated for the on-site office building with those for the main gate perimeter location, concentrations decrease significantly with distance from the public roads; therefore, impacts from road traffic to off-site receptors located some distance from the major public roads are expected to be negligible. To reduce the potential impact associated with site

TABLE C.6 Estimated PM-10 Concentrations from Traffic on Nearby Paved Public Roads for Current and Future Conditions[a]

Location of Potential Receptor	Current Conditions		Remedial Action Period	
	Maximum 24-Hour Concentration ($\mu g/m^3$)	Annual Average Concentration ($\mu g/m^3$)	Maximum 24-Hour Concentration ($\mu g/m^3$)	Annual Average Concentration ($\mu g/m^3$)
Francis Howell High School	12	4.5	14	5.3
Highway maintenance facility	12	4.1	14	5.0
On-site office building	5.1	1.6	6.2	1.8
Main gate guard post	28	9.4	34	12
South gate	6.9	2.4	8.0	2.8
North gate	9.1	2.1	11	2.4

[a] Current conditions are represented by traffic data for 1990; conditions for the remedial action period are represented by estimates for 1995, the worst-case year for this analysis.

traffic on these roads, a dust control program could be implemented during the remedial action period, which might include the following:

- Minimizing releases from the tires, undercarriages, and cargo of vehicles traveling to and from the site by cleaning the vehicles with water sprays before they enter public roads and by covering the cargo material (e.g., with tarps);
- Paving or oiling (with petroleum resin) the haul routes leading to the site; and
- Reducing road emissions by vacuum sweeping and/or pressurized water flushing.

C.1.3.5 Heavy Equipment Operations

Fugitive dust emissions can result from operating heavy construction equipment such as front-end loaders, bulldozers, and end-dump trucks, and these releases could impact on-site workers near the emission sources. Although diesel engines installed in heavy equipment generally emit low levels of hydrocarbons and carbon monoxide, they can emit a larger amount of nitrogen oxides. In addition, diesel smoke produced under fuel-rich driving conditions contains small carbon particles that can adsorb carcinogenic polycyclic aromatic hydrocarbons produced during combustion. Compared with the amount of fugitive dust associated with cleanup activities, however, the emissions from the exhaust of heavy equipment are expected to be relatively small. Hence, emissions were estimated for a screening-level analysis using information for a worst-case day.

To estimate impacts associated with exhaust pipe emissions and fugitive dust emissions, a front-end loader and a bulldozer were assumed to represent heavy equipment that would be used for cleanup activities. The maximum air pollutant concentrations at hypothetical receptors beyond the immediate work area are presented in Table C.7. These values were calculated using the exhaust emission factors for a four-wheel front-end loader (Caterpillar 966E) and the fugitive dust emission factors for a bulldozer (Caterpillar D6) at a fixed location, as given by AP-42. Pollutant concentrations from exhaust pipe emissions at receptors located at distances of 100 and 1,000 m (330 and 3,300 ft) from the source would be approximately 60 and 2% of those listed in Table C.7, and the concentrations would continue to decrease with distance. Because of the ground-level or near-ground-level nature of the releases, pollutant concentrations

TABLE C.7 Estimated Concentrations of Air Pollutants from Heavy Equipment Emissions

Air Pollutant	Averaging Period	Maximum Concentration from Exhaust Pipe Emissions ($\mu g/m^3$)	Maximum Concentration from Dust Emissions ($\mu g/m^3$)	Most Restrictive Standard[a] ($\mu g/m^3$)
Carbon monoxide	1 hour	150	-[b]	40,000
	8 hours	91	-	10,000
Nitrogen dioxide	1 year	5	-	100
Particulate matter (PM-10)	24 hours	9	420	150
	1 year	1	49	50
Sulfur oxides[c]	3 hours	37	-	1,300
	24 hours	9	-	365
	1 year	1	-	80
Lead	Calendar quarter	-	-	1.5
Ozone	1 hour	-	-	235

[a] Except for sulfur oxides, the most restrictive standards are primary air quality standards, which are based on health considerations. The secondary standards for all but carbon monoxide and sulfur oxides are the same as the primary standards. No secondary standard has been identified for carbon monoxide or for sulfur oxides on a 24-hour and annual average basis. For sulfur oxides, the 3-hour standard of 1,300 $\mu g/m^3$ is the secondary standard.

[b] A hyphen indicates that the value was not estimated or is not applicable.

[c] Expressed as sulfur dioxide.

from fugitive dust emissions would decrease with distance more rapidly than those from exhaust emissions. In summary, the impact of releases from heavy equipment sources to off-site receptors is expected to be negligible.

Control measures, such as using personal protective equipment and conducting operations upwind of emission sources, would be implemented to minimize the exposures of workers who periodically might find themselves next to exhaust emissions from heavy equipment. In particular, if emissions from a front-end loader expected to be operated in and around the volume reduction facility and sludge processing facility were to accumulate inside the building, they could impact workers inside. Appropriate engineering controls would be identified during the design phase of this remedial action to address this possibility.

C.2 METEOROLOGICAL DATA SUMMARY

Specific meteorological data used to model air quality include wind direction and speed, atmospheric stability, and mixing height. These parameters influence particulate transport and diffusion and are key inputs to modeling calculations. The following were considered as candidate meteorological data for input to the air quality modeling for the Weldon Spring site:

- Hourly wind direction, wind speed, and standard deviation of horizontal wind direction fluctuation (σ_θ) measured at a height of 10 m (33 ft) at the site (i.e., the chemical plant area) from 1983 to 1985;
- Hourly surface measurements taken at Lambert-St. Louis International Airport, a second-order National Weather Service station, from 1985 to 1989;
- Hourly wind direction and speed measured at Labadie Power Plant, both 10-m (33-ft) and 100-m (330-ft) towers, during 1985; and
- Twice-daily mixing height at Salem, Illinois (the nearest station at which this parameter is determined, located 160 km [100 mi] east of the site), during 1985.

Detailed descriptions of these nearby monitoring locations and data characteristics are discussed in Lazaro (1989).

The data selected for modeling air quality at the Weldon Spring site were 1985 surface meteorological data from the site and mixing height data from Salem, Illinois (the latter data were not available from on-site measurements). Background information related to selecting these data and statistical summaries of the key meteorological parameters are addressed in Sections C.2.1 through C.2.5. The potential impacts of these factors on local air quality during the remedial action period are also discussed.

C.2.1 Data Representativeness

The reliability of air quality model predictions depends primarily on the accuracy and representativeness of the input data. Therefore, use of meteorological data that are most representative of the area of interest is important to the accurate characterization of atmospheric dispersion (i.e., the transport and diffusion of airborne releases) and the development of control strategies for mitigating such releases. The EPA guidance on air quality modeling (EPA 1986) recommends the following: (1) meteorological data used as input to a dispersion model should be representative both spatially and temporally and (2) if 1 year or more (up to 5 years) of site-specific data are available, these data are preferred for use in the analysis.

The criterion of spatial representativeness addresses the collection of meteorological data from a location both close to the sources and receptors of interest and in the same climatological regime. Because meteorological data were collected at the Weldon Spring site for a period of at least 1 year (1985), these data are obviously most representative of the area being modeled.

Wind roses determined at selected monitoring stations in the vicinity of the Weldon Spring site for 1985 are shown in Figure C.3. The patterns of wind frequency distribution are similar for the site, the Lambert-St. Louis International Airport, and the 100-m (330-ft) tower at the Labadie Power Plant. The pattern at the Labadie Power Plant 10-m (33-ft) tower is somewhat different, with a high frequency of winds from the northeast and the southwest; these frequencies coincide with the bend of the Missouri River. (The power plant is located in the river valley, which is relatively flat but has steep slopes; the local terrain can significantly affect large-scale winds.) The wind roses for the area of concern for this analysis indicate that large-scale winds are primarily from the south and secondarily from the bearing between west and northwest.

The criterion of temporal representativeness addresses the yearly and/or seasonal variations in weather conditions. Meteorological data were collected at the site between April 1983 and December 1985. The data-capture efficiencies for on-site measurements were about 92 and 98% for 1984 and 1985, respectively. On the basis of the EPA (1986) recommendation that data recovery be ≥90%, both years of meteorological data are valid for modeling applications. However, because of a weather incident that interrupted data collection during 1984, the temporal representativeness of that year's data was determined to be inadequate. In September 1984, lightning struck and damaged the on-site instrumentation, resulting in 20 consecutive days over which data could not be collected. Thus, the seasonal characteristics for fall were distorted such that the 1984 data are considered less appropriate than the 1985 data for use in the modeling analysis. Therefore, only 1985 data were used for the analyses in this document.

To ensure that temporal variation was adequately considered, the on-site data for 1985 were compared with both on-site data for 1984 and nearby data for 1985 to 1989. As shown in Figure C.4, the frequency distributions for wind direction at the site are similar for 1984 and 1985. These distributions are also similar to those measured at the airport from 1985 to 1989, with slightly higher southerly winds and lower westerly winds (Figure C.3).

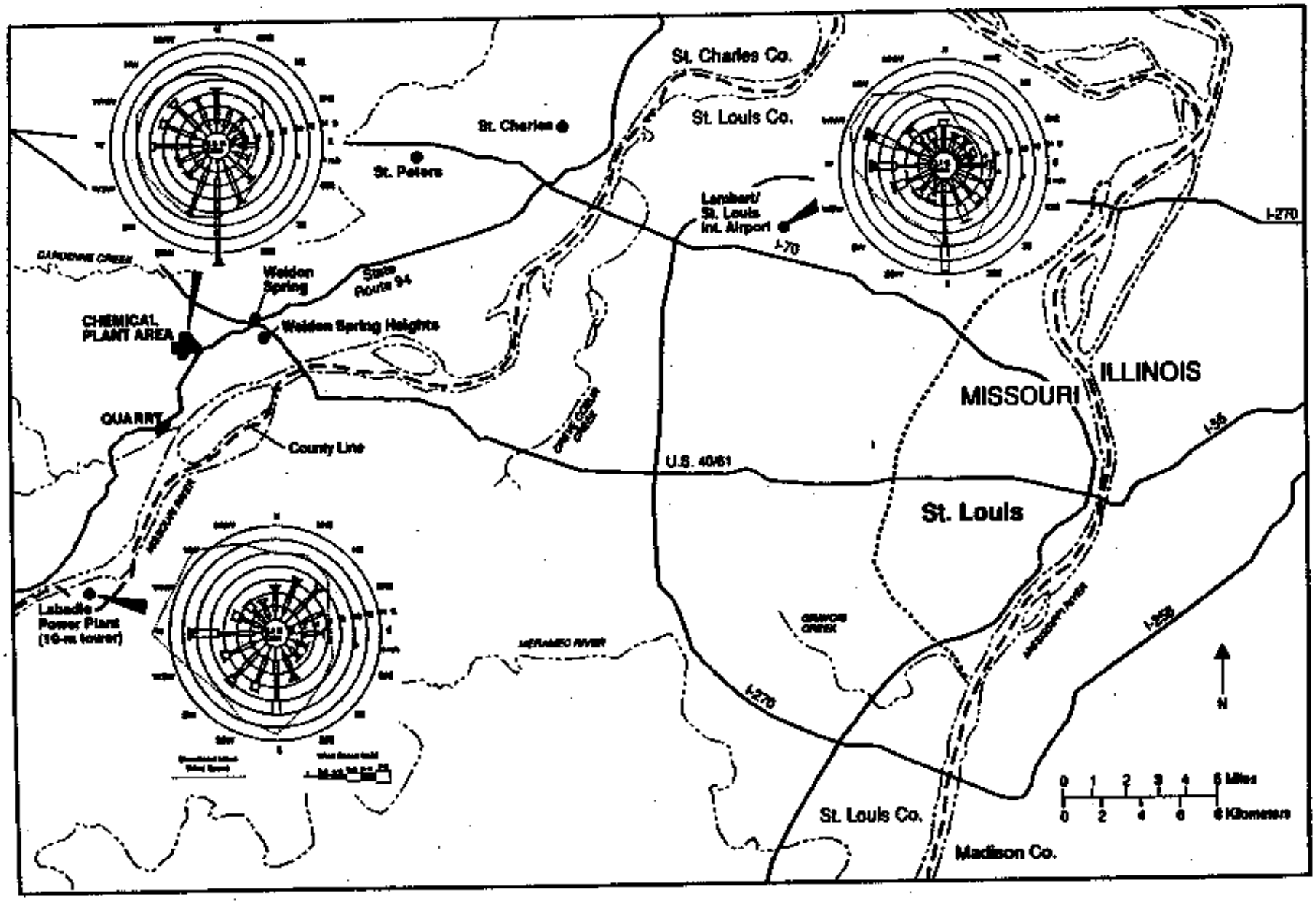

FIGURE C.3 Wind Roses from Selected Monitoring Stations in the Vicinity of the Weldon Spring Site, 1985

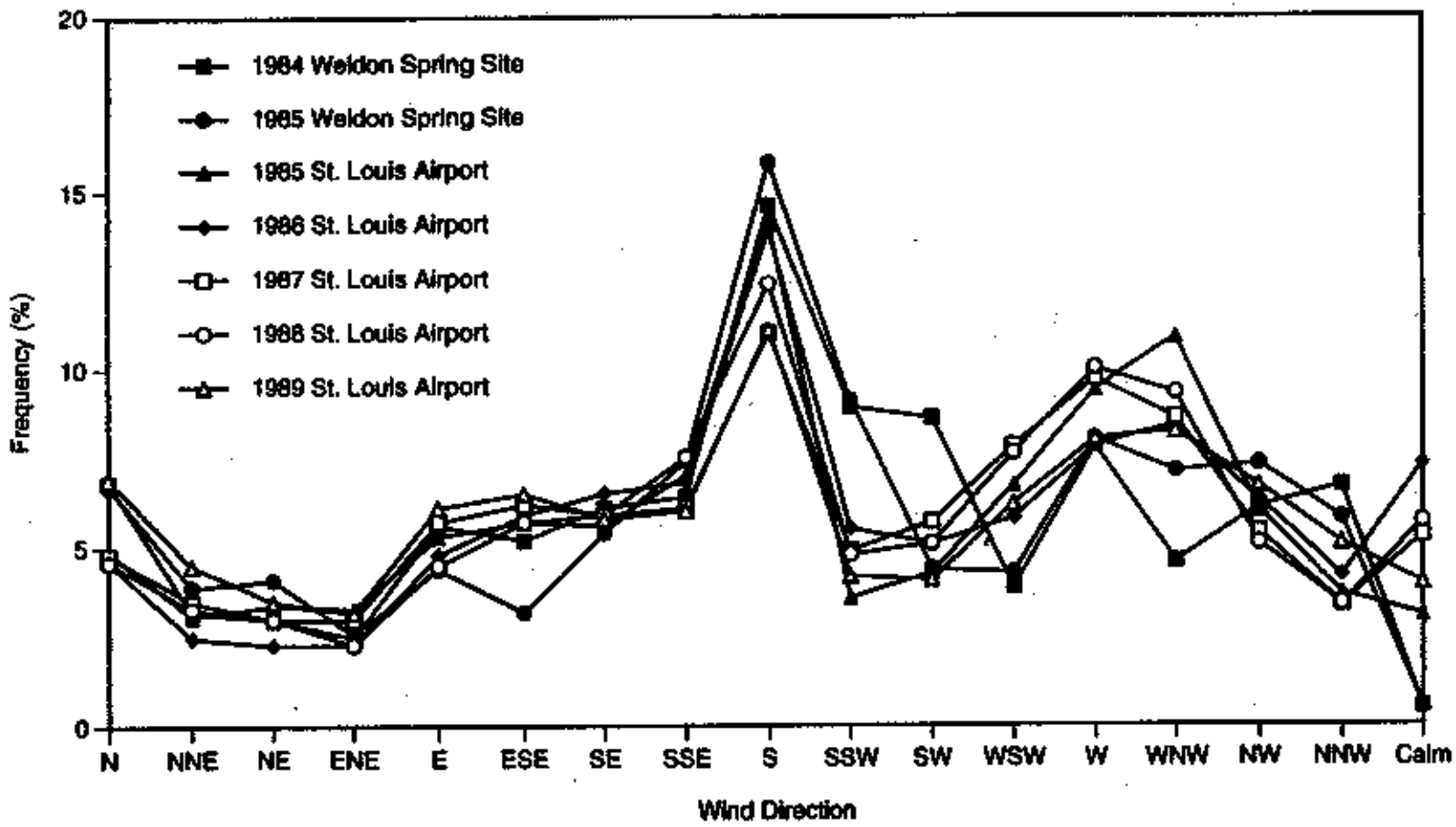

FIGURE C.4 Frequency Distributions for Wind Direction at the Weldon Spring Site, 1984-1985, and at the Lambert-St. Louis International Airport, 1985-1989

In summary, the meteorological data collected at the site during 1985 are considered both spatially and temporally representative. Therefore, these data were used to model air quality at the Weldon Spring site.

C.2.2 Wind Analysis

C.2.2.1 Wind Direction and Speed

The prevailing wind direction at the Weldon Spring site is from the south (Figures C.3 and C.4). Winds from the south-southeast to south-southwest, inclusive, occur at a frequency of 32%, and those from the west to north, inclusive, occur at a frequency of 35%. Directional wind speeds measured at the site range from 2.0 m/s from the east-northeast to 3.2 m/s from the west-northwest, with an annual average of 2.7 m/s. This annual average wind speed is lower than the speed of 4.7 m/s determined for Lambert-St. Louis International Airport. The difference is attributable to surface friction effects resulting from the heavy vegetation and relatively rough terrain in the site vicinity (e.g., to the south toward the Missouri River).

From 1983 to 1985, a wind speed of 12 m/s was measured only once at the Weldon Spring site (in January 1984); by comparison, this speed was measured at a frequency of 1% at the airport (about 90 times per year) from 1985 through 1989. A wind speed of greater than 11 m/s is considered to represent the magnitude of the threshold velocity sufficient to cause wind erosion. Thus, on the basis of site-specific data, wind erosion at the site is expected to be very low.

Seasonal daytime and nighttime wind roses for the site are presented in Figures C.5 and C.6. The only major difference between these wind patterns is that, year-round, directional wind speeds are higher during the daytime. In general, winds from the west to northwest prevail in the winter, and winds from the south prevail during the rest of the year. Except for the year-round operation of the vitrification facility, cleanup activities at the site would be conducted during a single daytime shift. Excavation activities are expected to stop during the 3 months of winter each year because of inclement weather and ground conditions; for Alternative 6a, the chemical treatment facility located near the raffinate pits (Section 5.2.2) would also cease operations during the 3-month winter shutdown. Thus, most of the fugitive dust would be released from the site during the other 9 months of the year, when prevailing winds are from the south. As a result, releases would generally be transported to the north, a direction in which no nearby receptors are currently present (Figure C.2). For Alternative 7a, 7b, or 7c, the vitrification facility would be operated 24 hours per day, 365 days per year. This facility would have a 30-m (100-ft) stack and would be at the same location as the chemical treatment facility for Alternative 6a. During winter operation of the vitrification facility, the prevailing winds from the west to the northwest would transport stack emissions to the southeast into the Weldon Spring Wildlife Area. Therefore, impacts to potential off-site receptors associated with atmospheric transport following airborne releases are expected to be minimal.

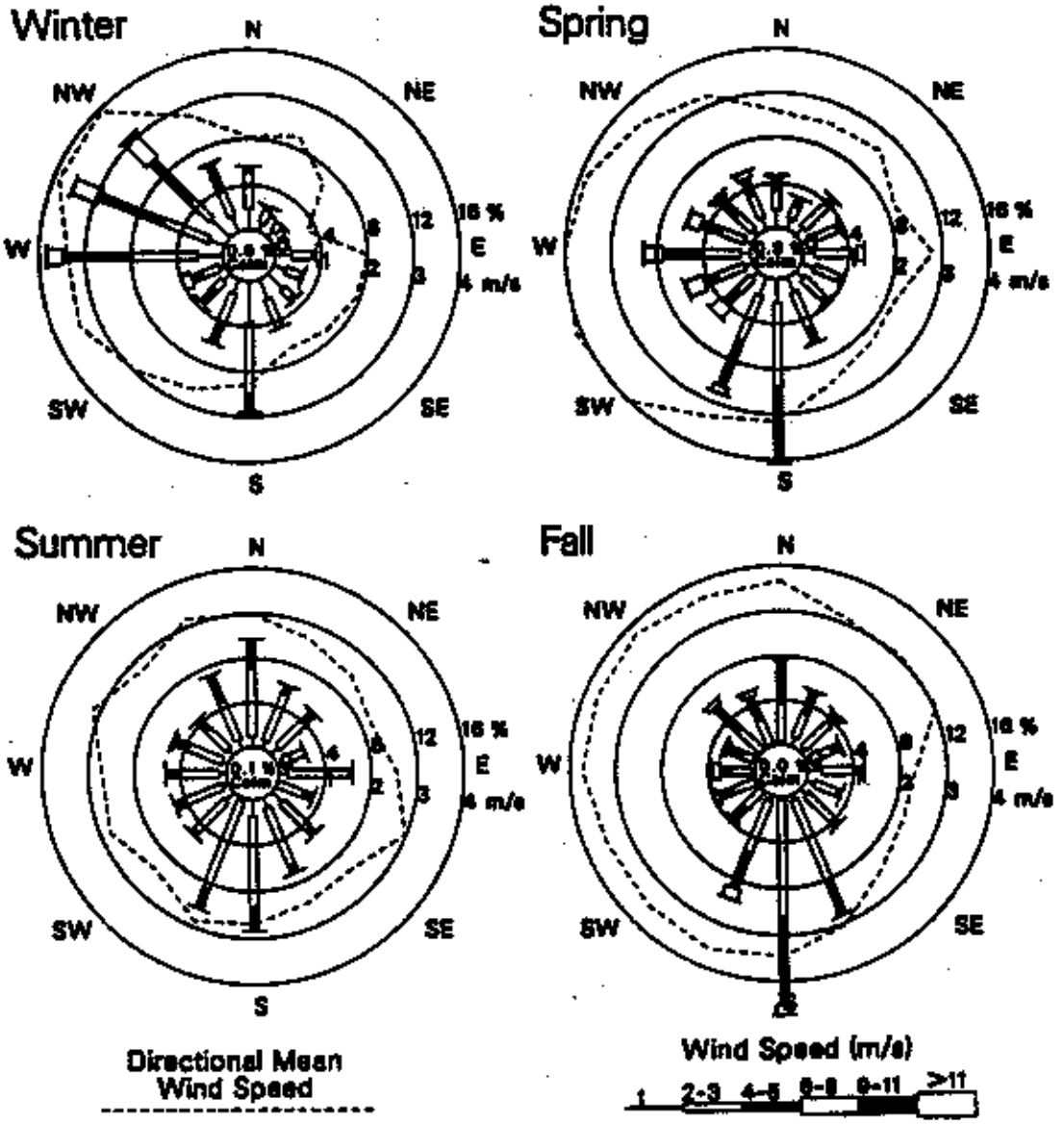

FIGURE C.5 Seasonal Daytime Wind Roses at the Weldon Spring Site, 1985

C.2.2.2 Wind Persistence

Air pollution episodes can occur when the wind direction remains constant over an extended period of time. The frequency distribution of wind direction persistence at the site for 1985 is presented in Table C.8. This distribution indicates that the dominant southerly winds persist for longer periods than those from any other direction; in one instance, the wind remained invariant from the south for more than 25 hours. During 1985, westerly winds persisted once for 20 hours and west-southwesterly winds persisted once for 8 hours. Such winds could potentially create a short-term impact at Francis Howell High School because of its location relative to the site (Figure C.2). Winds that could impact the on-site office building are

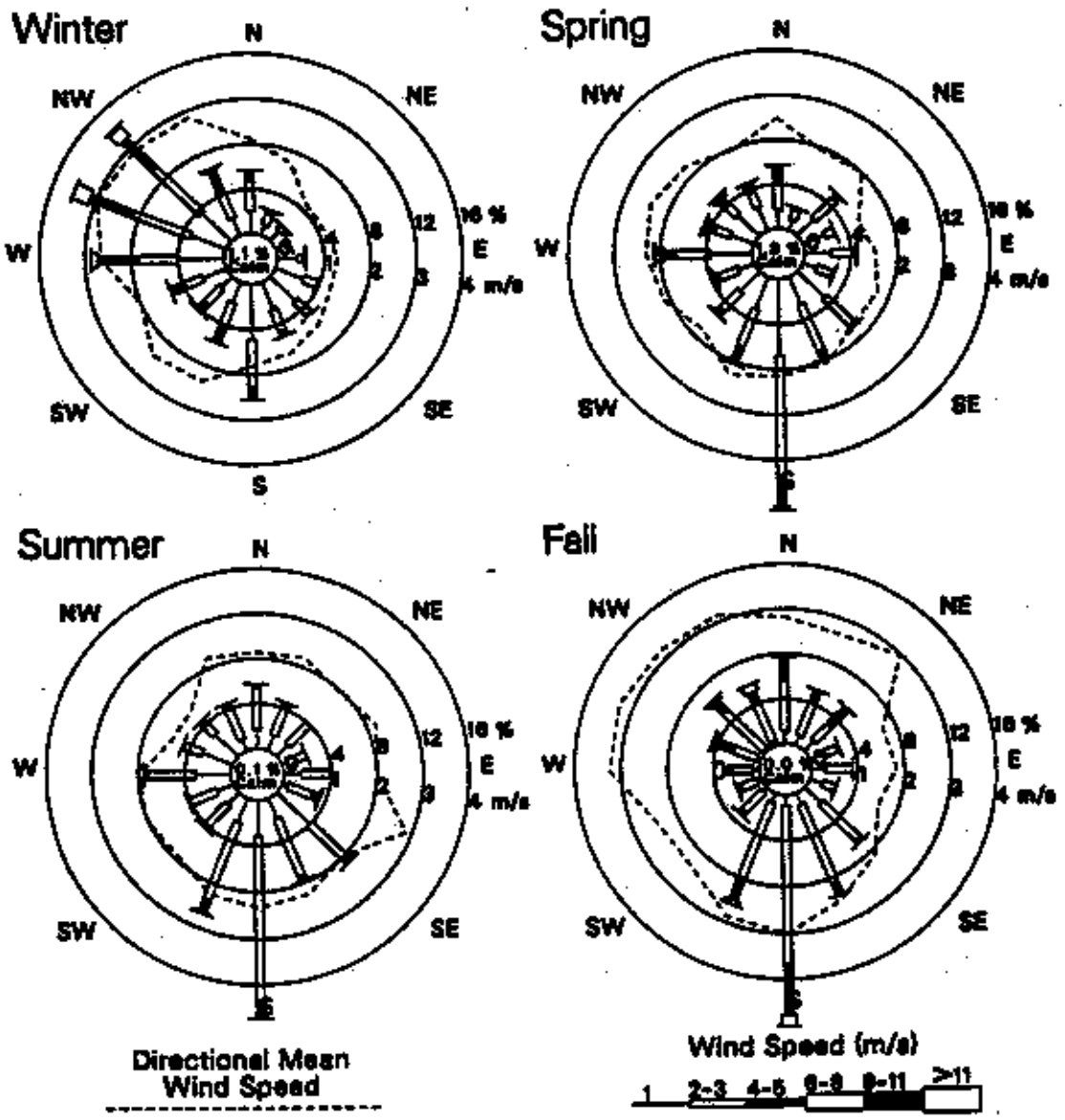

FIGURE C.6 Seasonal Nighttime Wind Roses at the Weldon Spring Site, 1985

those that blow from the west-southwest and clockwise to the north-northeast. Of these, the longest persistence during 1985 occurred from the west for 20 hours, and the second longest persistence occurred from the west-northwest and northwest for 18 hours.

The persistence of surface winds with slower speeds (e.g., 3.1 m/s) combined with persistent wind direction can be conducive to the accumulation of air pollutants. The frequency distribution of wind speed persistence at the Weldon Spring site for 1985 is summarized in Table C.9. Wind speeds between 2 and 3 m/s occurred most often at the site, and they persisted for 2 consecutive hours approximately 50% of the year and for more than 25 consecutive hours a total of 16 times. Wind speeds of 1 m/s, the second highest value, persisted for 2 consecutive

TABLE C.8 Frequency Distribution of Persistent Wind Direction at the Weldon Spring Site, 1985

Persistence (hours)	Frequency of Persistent Wind Direction[a]																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
1	6.7	3.9	4.1	2.5	4.4	3.3	5.5	7.5	15.9	9.1	4.4	4.3	8.0	7.1	7.4	5.9	100.0
2	5.1	2.6	2.9	1.5	3.2	1.9	3.7	5.4	13.6	6.8	2.4	2.6	6.1	4.9	5.3	4.0	71.8
3	3.8	1.9	2.0	0.8	2.3	1.1	2.5	3.7	11.4	5.1	1.2	1.4	4.7	3.7	3.7	2.6	51.8
4	2.9	1.1	1.5	0.4	1.7	0.7	1.8	2.5	9.8	3.8	0.7	1.0	3.6	2.9	2.6	1.7	38.6
5	1.9	0.7	1.2	0.3	1.2	0.4	1.2	1.8	8.2	2.9	0.6	0.7	2.8	2.3	1.7	0.9	28.7
6	1.7	0.5	0.9	0.1	1.0	0.3	0.7	1.3	6.3	2.1	0.3	0.4	2.2	1.9	1.6	0.7	21.7
7	1.3	0.4	0.5	0.0	1.0	0.2	0.4	0.8	4.9	1.5	0.2	0.3	1.7	1.4	1.3	0.4	16.3
8	0.7	0.2	0.5	0.0	0.7	0.1	0.2	0.7	4.4	1.2	0.2	0.1	1.6	1.1	1.1	0.4	13.1
9	0.6	0.1	0.5	0.0	0.7	0.0	0.1	0.5	3.8	1.0	0.0	0.0	1.5	1.1	0.9	0.3	11.1
10	0.4	0.1	0.2	0.0	0.7	0.0	0.1	0.3	3.1	0.5	0.0	0.0	1.5	0.7	0.8	0.1	8.5
11	0.2	0.1	0.0	0.0	0.7	0.0	0.1	0.3	2.8	0.5	0.0	0.0	1.3	0.6	0.8	0.1	7.6
12	0.2	0.1	0.0	0.0	0.6	0.0	0.1	0.1	2.3	0.2	0.0	0.0	1.1	0.4	0.7	0.0	5.8
13	0.2	0.0	0.0	0.0	0.4	0.0	0.0	0.0	1.6	0.2	0.0	0.0	0.9	0.2	0.5	0.0	4.1
14	0.2	0.0	0.0	0.0	0.4	0.0	0.0	0.0	1.6	0.2	0.0	0.0	0.9	0.2	0.4	0.0	3.9
15	0.2	0.0	0.0	0.0	0.4	0.0	0.0	0.0	1.4	0.2	0.0	0.0	0.6	0.2	0.2	0.0	3.3
16	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.3	0.2	0.0	0.0	0.4	0.2	0.2	0.0	2.6
17	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.3	0.2	0.0	0.0	0.4	0.2	0.2	0.0	2.6
18	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.1	0.2	0.0	0.0	0.2	0.2	0.2	0.0	2.2
19	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	1.5
20	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	1.5
21	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
22	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
≥25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5

[a] Frequency as percent of total measurements.

TABLE C.9 Wind Speed Persistence at the Weldon Spring Site, 1985

Duration (hours)	Frequency by Wind Speed Class[a]							
	Calm	1 m/s	2-3 m/s	4-5 m/s	6-8 m/s	9-11 m/s	>11 m/s	Total
1	0.5	22.9	51.8	20.8	3.8	0.2	0.0	100.0
2	0.2	21.1	49.4	18.8	3.3	0.1	0.0	92.8
3	0.2	19.1	46.8	16.7	2.6	0.1	0.0	85.5
4	0.2	17.5	43.7	14.6	2.1	0.1	0.0	78.1
5	0.1	16.1	40.2	12.9	1.9	0.0	0.0	71.2
6	0.1	15.1	36.8	10.9	1.6	0.0	0.0	64.4
7	0.1	13.9	34.6	9.4	1.4	0.0	0.0	59.3
8	0.0	13.3	31.6	7.6	1.0	0.0	0.0	53.5
9	0.0	11.6	28.8	6.5	0.9	0.0	0.0	47.6
10	0.0	10.0	26.9	5.6	0.9	0.0	0.0	43.3
11	0.0	9.3	24.8	4.7	0.6	0.0	0.0	39.4
12	0.0	8.6	22.3	4.1	0.4	0.0	0.0	35.4
13	0.0	7.2	20.7	3.5	0.2	0.0	0.0	31.5
14	0.0	6.2	18.6	3.2	0.2	0.0	0.0	28.1
15	0.0	5.4	16.2	2.7	0.2	0.0	0.0	24.4
16	0.0	5.0	14.3	2.7	0.2	0.0	0.0	22.2
17	0.0	3.7	13.2	2.1	0.2	0.0	0.0	19.3
18	0.0	3.1	11.5	1.7	0.2	0.0	0.0	16.6
19	0.0	2.9	10.4	1.7	0.2	0.0	0.0	15.3
20	0.0	2.3	10.2	1.7	0.2	0.0	0.0	14.4
21	0.0	2.3	9.7	1.1	0.0	0.0	0.0	13.1
22	0.0	1.8	9.5	0.8	0.0	0.0	0.0	12.1
23	0.0	1.6	8.5	0.8	0.0	0.0	0.0	10.9
24	0.0	1.6	8.2	0.3	0.0	0.0	0.0	10.1
≥25	0.0	1.3	6.9	0.3	0.0	0.0	0.0	8.4

[a] Frequency as percent of total measurements.

hours approximately 21% of the year, whereas wind speeds greater than 9 m/s rarely occurred. These data indicate that the persistence of winds with slower speeds at the site could potentially impact nearby receptors. However, these impacts are not expected to be significant because wind persistence in the direction of current off-site receptors is infrequent and cleanup activities would be conducted during a single daytime shift, except at the vitrification facility. Because stack emissions would be limited by stringent engineering controls (Section C.3.4), even the year-round operation of this facility is not expected to impact local air quality.

C.2.3 Atmospheric Stability

The stability of the atmosphere is defined as its tendency to resist or enhance vertical motion or to lessen or augment existing turbulence. The degree of atmospheric turbulence depends largely on the vertical temperature gradient, and it can be affected to some extent by surface roughness, wind speed, and wind shear.

Atmospheric stability classes used in air quality modeling are usually estimated by the objective method of Turner (1964), which incorporates information on the amount of insolation, cloud cover, cloud ceiling height, and 10-m (33-ft) wind speed. Because site-specific data are not available for cloud cover and cloud ceiling height, on-site measurements of the standard deviation of horizontal wind direction (σ_θ) were used to determine the stability categories for modeling air quality (see Lazaro [1989] for detailed estimation procedures). The site stability class data were determined according to EPA methodology (EPA 1986), and the airport data were evaluated with Turner's method for the comparative analysis. The 1985 annual distributions of stability classes at the site and Lambert-St. Louis International Airport (St. Louis Airport) are presented in Figure C.7. The distributions of stability classes at these two locations have very similar patterns. In 1985, neutral conditions (Class D) occurred most frequently at the Weldon Spring site, i.e., 53% of the time; stable conditions (Classes E and F) and unstable conditions (Classes A, B, and C) occurred 30 and 17% of the time, respectively. Stability conditions are not expected to adversely impact air quality during the cleanup period because most activities would be conducted during the day when Classes A through D predominate, i.e., when atmospheric dispersion is generally enhanced.

C.2.4 Diurnal Patterns of Wind Speed, Wind Direction, and Atmospheric Stability Class

Diurnal patterns of wind speed, wind direction, and atmospheric stability class for the site are presented in Table C.10; these patterns are based on the site-specific data for 1985. Winds from the south were most frequent for all hours of the day. The daytime wind speed averaged about 3 m/s, with a maximum of 3.4 m/s occurring between noon and 2 p.m. Neutral (Class D) and slightly stable (Class E) conditions were most frequent during the day and night, respectively.

C.2.5 Mixing Height

Mixing height is the height above ground to which relatively unrestricted vertical mixing can occur. When the mixing height is low just after sunrise, ground-level concentrations of airborne contaminants are relatively high because of limited mixing. For this analysis, mixing heights for the site were estimated from upper-air meteorological measurements taken twice daily in 1985 at Salem, Illinois; the seasonal and annual morning and afternoon average mixing heights for 1985 estimated from these data are presented in Figure C.8. The annual average mixing heights for morning and afternoon are 530 and 1,170 m (1,700 and 3,800 ft), respectively. The lowest seasonal mixing heights are 470 m (1,500 ft) for a fall morning and 790 m (2,600 ft) for a winter afternoon.

Most of the emission sources associated with remedial action activities at the Weldon Spring site would be ground-level or near-ground-level nonbuoyant releases, and most cleanup activities would begin after the mixing height had been considerably developed. Hence, mixing height is considered an insignificant factor relative to potential pollutant concentrations that would result from emissions generated by cleanup activities. However, mixing height could

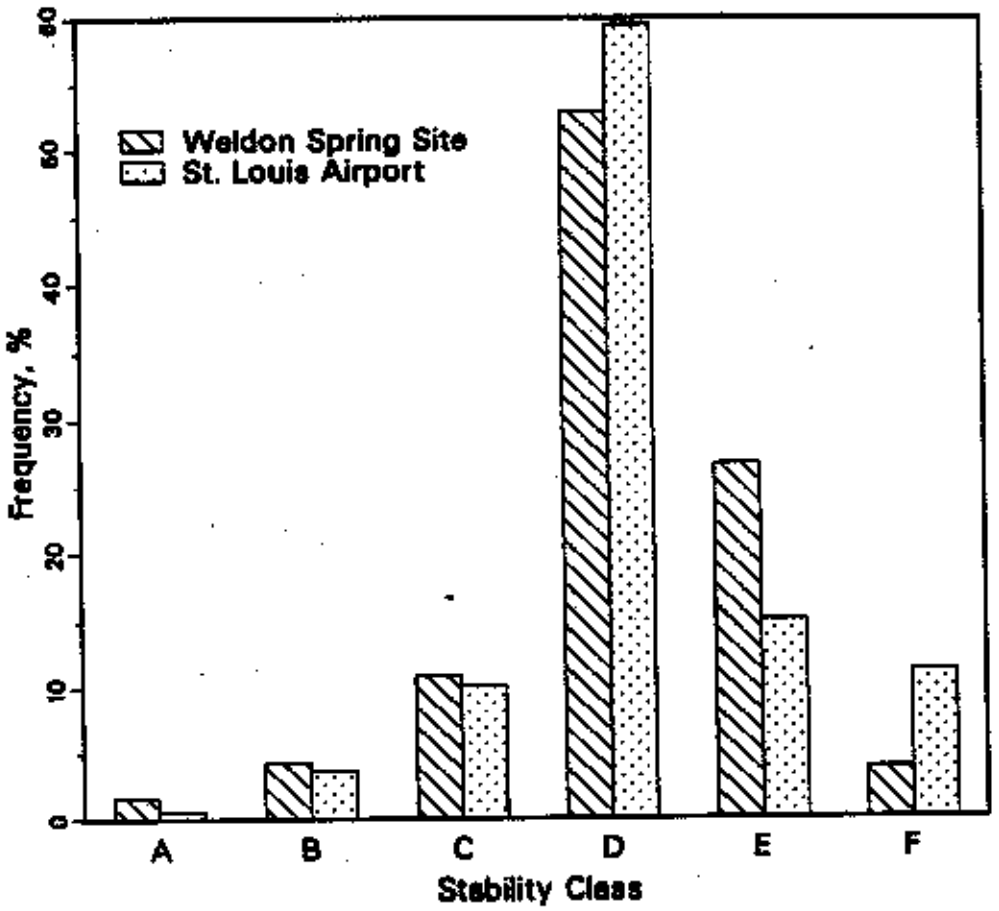

FIGURE C.7 Frequency Distribution of Atmospheric Stability Classes at the Weldon Spring Site and Lambert-St. Louis International Airport, 1985

potentially play a significant role relative to stack emissions from the vitrification facility. In the early morning hours when the sun heats the land surface, the nighttime temperature inversion is eroded from the ground surface upward and the mixing height can temporarily be quite low; this can cause an unfavorable atmospheric mixing condition known as fumigation. Under this condition, ground-level concentrations might be elevated in the immediate vicinity of the stack. Nevertheless, mixing height is not expected to adversely impact air quality because the off-gas treatment system is expected to efficiently control stack emissions so that releases would be very small.

C.3 METHODOLOGY FOR ESTIMATING PARTICULATE EMISSIONS

Emissions from the various sources of fugitive dust at the Weldon Spring site were estimated on the basis of (1) the types of remedial action activities being considered, (2) PM-10 emission factors and source definitions, and (3) the types and efficiencies of engineering controls for reducing emissions. Emissions were not estimated in detail for criteria pollutants other than

TABLE C.10 Diurnal Patterns of Wind Direction, Speed, and Stability Class at the Weldon Spring Site, 1985

Local Time	Most Frequent Wind Direction	Average Wind Speed (m/s)	Most Frequent Stability Class
Midnight	S	2.3	Slightly stable (E)
1 a.m.	S	2.3	Slightly stable (E)
2 a.m.	S	2.3	Slightly stable (E)
3 a.m.	S	2.3	Slightly stable (E)
4 a.m.	S	2.3	Slightly stable (E)
5 a.m.	S	2.2	Neutral (D)
6 a.m.	S	2.2	Neutral (D)
7 a.m.	S	2.5	Neutral (D)
8 a.m.	S	2.7	Neutral (D)
9 a.m.	S	2.9	Neutral (D)
10 a.m.	S	3.1	Neutral (D)
11 a.m.	S	3.2	Neutral (D)
Noon	S	3.4	Neutral (D)
1 p.m.	S	3.4	Neutral (D)
2 p.m.	S	3.4	Neutral (D)
3 p.m.	S	3.3	Neutral (D)
4 p.m.	S	3.2	Neutral (D)
5 p.m.	S	2.9	Neutral (D)
6 p.m.	SSE	2.6	Neutral (D)
7 p.m.	S	2.3	Neutral (D)
8 p.m.	S	2.2	Slightly stable (E)
9 p.m.	S	2.2	Slightly stable (E)
10 p.m.	S	2.3	Slightly stable (E)
11 p.m.	S	2.2	Slightly stable (E)

PM-10 (e.g., for those pollutants that could be released from the stack of the vitrification facility or from the exhaust pipes of heavy construction equipment) because they would be negligible compared with dust emissions. Therefore, screening-level model calculations were developed for those pollutants to provide an indication of their impacts on local air quality (Section C.1.3).

The potential fugitive dust sources associated with cleanup activities at the site are identified in Section C.3.1. Emission rates were characterized for each source area to (1) evaluate the activities that would contribute most significantly to fugitive dust emissions, (2) support the risk assessment for the remedial action period and the evaluation of short-term effectiveness for the final alternatives, and (3) identify the appropriate locations for and types of dust control measures. The emission factors and the extent of the source areas used to develop the uncontrolled PM-10 emission inventory are discussed in Sections C.3.2 and C.3.3, respectively. The estimated PM-10 emission inventories for Alternatives 6a and 7a are presented in Section C.3.4. Conventional dust control measures expected to be used during the remedial action period are discussed in Section C.3.5.

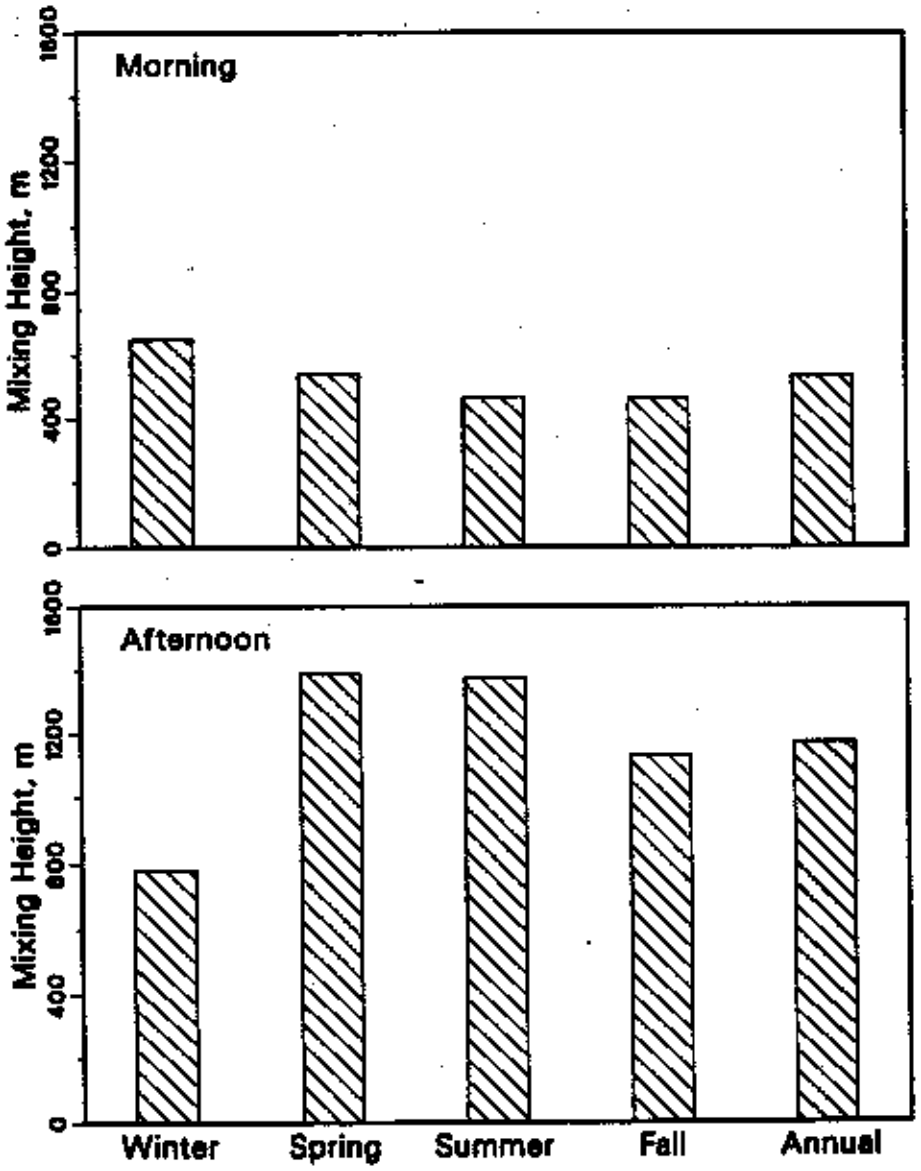

FIGURE C.8 Seasonal Morning and Afternoon Mixing Heights at Salem, Illinois, 1985

C.3.1 Remedial Action Activities

During the cleanup period, fugitive dust releases could result from the following:

- Operation of heavy equipment at each activity area, e.g., for excavating, scraping, grading, and compacting;
- Loading and unloading of material at each source area and at staging areas and stockpiles;
- Transportation of waste from a contaminated area to a staging or treatment area, as appropriate, with final transportation to the disposal cell;

- Operation of treatment facilities, including material handling, preparation, and treatment activities at the sludge processing facility and the volume reduction facility;

- Dismantling of temporary facilities;

- Placement of waste in the disposal cell, including dumping, grading, and compacting;

- Wind erosion at exposed work areas and stockpiles of contaminated soil or uncontaminated construction and backfill material; and

- Miscellaneous transportation, such as operation of worker/visitor and supply vehicles and road maintenance activities such as grading.

General assumptions for emission inventories and air quality modeling were made on the basis of preliminary engineering information developed for site-specific cleanup activities by MK-Ferguson Company and Jacobs Engineering Group (1992). This information includes processing rates and expected equipment selections for each activity, as determined from factors such as material type and thickness, moisture content, and haul distance. The following basic assumptions have been used in the air pathway modeling for the Weldon Spring site:

- *Operating Time:* Cleanup activities for each source area would be conducted independently; these activities would occur during one 8-hour shift per day, 5 days per week, 20 days per month, over a 9-month work year, with 3 months of winter shutdown to account for inclement weather and equipment maintenance unless otherwise noted. The exceptions related to vitrification operations are (1) the vitrification process would operate 24 hours per day, 365 days per year; (2) contaminated soil would be delivered to the treatment facility 8 hours per day, 20 days per month, 12 months per year (with stockpiling in an enclosed container); and (3) sludge would be dredged and pumped from the raffinate pits to the facility 8 hours per day, 20 days per month, 10 months per year.

- *Waste to the Sludge Processing Facility:* Sludge would be dredged and pumped as a slurry directly from the raffinate pits to the sludge processing facility for treatment. After the sludge was removed from the pits, the contaminated soil around and beneath the pits that is targeted for treatment (e.g., the embankment soil and clay bottom material) would be removed with conventional excavation equipment and transported to the TSA for stockpiling with the quarry soil. Soil would be transferred by a front-end loader from the TSA to the sludge processing facility for treatment.

- *Swell Factor:* The volume of excavated material was assumed to increase by 20% over the in-place volume as a result of natural loosening and "fluffing." However, no swell factor was applied to the sludge dredged from the raffinate pits because of its comparatively high water content (70 to 80% by weight).

- *Characteristics of Treated Material:* Compared with the initial waste material, the volume and weight of chemically treated material were assumed to increase by about 30 and 60%, respectively. This material would resemble a grout-like mixture and would have an initial moisture content of more than 30%. The volume and weight of vitrified material were assumed to decrease by about 70% and 50%, respectively. The vitrified product would be in the form of fritted glass. Handling these treatment products is not expected to result in fugitive dust emissions.

- *Stockpiling:* Stockpiling would be minimized to the maximum extent practicable, e.g., by optimizing and planning in advance for material needs.

- *Gate Entry:* Additives for chemical stabilization, off-site borrow material for backfill, topsoil for seeding beds, and construction material for the cell would be delivered to the site through existing gates, e.g., the north gate.

- *Access Roads:* The access roads used to connect State Route 94 to the site would be paved, and on-site haul routes would be covered with crushed limestone.

- *Truck Haulage:* The estimated number of truckloads is based on the total volume of material that would have to be hauled, assuming an average cargo density of about 1.5 g/cm^3; the primary haul vehicle would be an 8-m^3 (10-yd^3) end-dump truck.

- *Miscellaneous Transport:* Miscellaneous transport would occur daily to accommodate workers and visitors and to transfer supplies and other material between on-site areas; eight round trips are estimated for worker/visitor vehicles, two for supply trucks (e.g., for fuel and lubrication oil), four for a water truck, and one for a road grader.

Emission factors and the extent of source areas for the activities described above are addressed in Sections C.3.2 and C.3.3, respectively.

C.3.2 Emission Factors

Emission factors were estimated from standard reference sources (EPA 1985-1988, 1989a), equipment specifications provided in the *Caterpillar Performance Handbook* (Caterpillar 1989), and professional engineering judgment. The conventional construction equipment that

would probably be used was identified on the basis of conceptual project planning information (MK-Environmental Services 1990; Morrison-Knudsen Company 1991; MK-Ferguson Company and Jacobs Engineering Group 1992). The emission factors estimated for the various remedial action activities are presented in Table C.11. The parameters used to estimate uncontrolled emissions for specific cleanup operations are described in the Section C.3.2.1.

C.3.2.1 Input Parameters

The basic input parameters used to estimate emission factors for material handling activities such as excavating, dumping, grading, and hauling include silt content, moisture content, mean wind speed, vehicle speed, and other climatic data. The specific input parameters used in this analysis were:

- *Silt Content:* The contaminated soil on-site and the uncontaminated borrow soil off-site consist primarily of silt and clay, which are relatively fine partic'es. Results of a site geotechnical survey indicated that the silt content of soil at and around the site ranges from 65 to 75%. However, this value must be adjusted to account for the effects of cohesion and the plasticity of fine particles under field conditions, as supported by site analyses (Grozescu 1991). Using a site-specific adjustment factor, a silt content of 30% was derived for this analysis. Haul roads were assumed to be covered with crushed limestone, for which the typical silt content of 9.6% was assumed (Section 11.2.1 of AP-42).

- *Moisture Content:* The geotechnical survey also determined that the moisture content of on-site and off-site soil can vary from 14 to 20% and higher; an average value of 17% was assumed for this analysis (Grozescu 1991). A value of 40% was used for the moisture content of Frog Pond sediment, and the water content of the raffinate pit sludge was determined to be 73% (MK-Environmental Services 1990).

- *Vehicle Speed:* An average vehicle speed of 16 km/h (10 mph) was assumed for haulage and delivery trucks at the site; a mean vehicle speed of 40 km/h (25 mph) was assumed for worker/visitor transport vehicles; and a mean vehicular speed of 8 km/h (5 mph) was assumed for the front-end loader, road grader, and water-spraying truck used for dust control.

- *Mean Wind Speed:* A mean wind speed of 4.2 m/s has been identified for the St. Louis area (Cowherd et al. 1985). This value was used to calculate wind-driven emissions from dumping operations and from moving uncovered truckbeds.

TABLE C.11 Uncontrolled PM-10 Emission Factors Used to Develop Emission Inventories

Emission Source Category	Equipment[a]	Capacity	Material Handled[b]	Emission Factor	Unit[c]
Chemical treatment	Pug mill mixer	140 tons/h[d]	Soil and sludge	0.1	lb/ton
Vitrification	Fossil fuel-heated ceramic melter	200 tons/d[d]	Soil and sludge	0.023[e]	lb/d
Volume reduction	Impact crusher (200 hp) Rotary shear (200 hp) Compactor (10 hp)		Rock and structural material	0.017	lb/ton
Excavation	Bulldozer/Caterpillar D6, D8		General	2.33[f]	lb/h
	Bulldozer/Caterpillar D6, D8		Sediment	0.70	lb/h
	Front-end loader/Caterpillar 916	11 tons	General	1.51	lb/VMT[g]
	Front-end loader/Caterpillar 936	15 tons	General	1.94	lb/VMT
	Front-end loader/Caterpillar 966	25 tons	General	2.76	lb/VMT
Scraping (travel mode)	Scraper/Caterpillar 613	23 tons	Soil	1.08	lb/VMT
	Scraper/Caterpillar 631	67 tons	Soil	5.53	lb/VMT
Dumping[h]	End-dump truck/Ford F800		General	0.0012	lb/ton
			Sediment	0.0004	lb/ton
Grading	Grader/Caterpillar 12G		General	0.77	lb/VMT
Compaction	Compactor/Raygo 400, 600		General	1.17	lb/h
			Sediment	0.35	lb/h
Facility dismantlement	Crane, bulldozer/Caterpillar D6		Structural material	0.0025	lb/ton
Debris loading	End-dump truck/Ford F800		Structural material	0.0025	lb/ton
Debris bulldozing	Bulldozer/Caterpillar D6		Structural material	0.75	lb/h

TABLE C.11 (Cont.)

Emission Source Category	Equipment[a]	Capacity	Material Handled[b]	Emission Factor	Unit[c]
Vehicular traffic on unpaved road	End-dump truck/Ford F800	10 yd^3	General	2.56	lb/VMT
	Front-end loader/Caterpillar 916	11 tons	General	0.48	lb/VMT
	Front-end loader/Caterpillar 966	25 tons	General	0.88	lb/VMT
	Worker/visitor vehicle		Not applicable	0.99	lb/VMT
	Supply truck		Fuel, lubrication oil	0.54	lb/VMT
	Supply truck		Fly ash and cement	4.06	lb/VMT
	Water truck		Water for dust control	1.19	lb/VMT
Uncovered truckbed or front-end loader bed	End-dump truck or front-end loader		General	0.001	lb/yd^2-h
Wind erosion	Not applicable		General	9.84	lb/d-acre

[a] Represents the types of standard equipment that could be used for various cleanup activities; Caterpillar is a product of Caterpillar Company (Caterpillar, Inc. 1989), Raygo is a product of Raygo Company (MK-Ferguson Company and Jacobs Engineering Group 1992), and Ford is a product of Ford Motor Company (MK-Ferguson Company and Jacobs Engineering Group 1992).

[b] "General" means general handling of soil and process material, unless otherwise noted.

[c] The designation lb/ton means pounds emitted per ton of material processed; lb/d = pounds emitted per day; the combinations of pounds (lb) with other units are similarly defined.

[d] Site-specific design capacity.

[e] Refers to the controlled emission factor; an emission factor for uncontrolled operations was not estimated because these operations would be controlled at the site.

[f] Half the given emission factor is applied for the backhoe and front-shovel operations.

[g] VMT = vehicle-miles traveled.

[h] Refers to dumping onto a receiving surface such as a truckbed, staging area, processing bin, or disposal cell.

- *Other Climatic Data:* The number of days with at least 0.01 inches of precipitation per year — defined as the climatic correction factor — was assumed to be 110 on the basis of information available for the St. Louis area (from Figure 11.2.1-1 of AP-42).

Fugitive dust is not expected to be generated by dredging the raffinate pit sludge because the sludge has a high water content (73%). Similarly, because of the solid form of the treated product resulting from either chemical stabilization/solidification or vitrification (grout or glass, respectively), emissions from handling would essentially be insignificant.

The moisture and silt contents of on-site soil are relatively high compared with the ranges of source conditions tested in developing the EPA emission factor equations (e.g., in AP-42). To avoid deriving unreasonable values from the emission factor equations because of inconsistent assumptions, certain adjustments were made to these values, as described in Sections C.3.2.2 through C.3.2.13. Additional parameters related to specific material-handling activities are also discussed.

C.3.2.2 Chemical Stabilization/Solidification

Fugitive dust emissions associated with the chemical stabilization/solidification process could result from storing raw material (such as fly ash or cement), preparing binding agents, loading waste and binding agents into the mixer, and discharging the stabilized material from the mixer into the fill bin. A standard emission factor is not available for this specific process; therefore, chemical stabilization/solidification was conservatively assumed to be similar to the process at a concrete batching plant, which also involves mixing with fly ash, cement, or lime-kiln dust and for which an emission factor is available (EPA 1989a). A single-value emission factor was adopted for total suspended particulates (TSP) to provide an overall estimate of PM-10 emissions for all activities at the sludge processing facility, ranging from material transfer (e.g., from the storage piles to the treatment system) to discharge of the final product. Use of this emission factor as the value for PM-10 is conservative because (1) PM-10 represents a fraction of the TSP and (2) emission controls that are not applied at a typical concrete batching plant — at which material is uncontaminated — would certainly be applied at the chemical treatment facility because contaminated material would be involved.

C.3.2.3 Vitrification

The PM-10 emission factor for the vitrification process was estimated on the basis of vendor information, test results, and data from a literature survey (MK-Ferguson Company and Jacobs Engineering Group 1992). In addition, emissions of metals were included in the estimated total PM-10 emission factor, assuming that most metals would be condensed onto particles in the off-gas stream. An uncontrolled emission factor was not estimated because operations would be controlled. For example, contaminated material would be transferred in enclosed systems and the off gas would pass through air pollution control devices. Other emission factors for activities

such as material loading/unloading and vehicular traffic in the facility are addressed in the following discussions.

C.3.2.4 Volume Reduction

Both on-site and off-site disposal alternatives would include volume reduction operations, primarily to decrease the volume and size of rock and structural material from the MSA and TSA. No appropriate emission factors are currently available for this type of operation as it would be applied at the site. Thus, the single-value emission factor developed for crushing operations of primary or secondary dry materials, given in Section 8.19.2 of AP-42, was used for this analysis.

C.3.2.5 Excavation

During the remedial action period, soil and some sediment would be excavated from contaminated areas (e.g., Ash Pond) and from uncontaminated locations to be used for staging areas or for construction of temporary facilities. Standard excavation equipment that is expected to be used includes bulldozers, backhoes, front shovels, wheeled front-end loaders, and scrapers. The specific equipment used for a given activity at a given area would depend on the physical characteristics of the material being handled. Input for the silt and moisture content of the material that would be handled at the site is addressed in Section C.3.2.1.

Emission factors for the excavation equipment were based on the predictive equation for the bulldozer emission factor given in Section 8.24 of AP-42. Because similar factors are not available for a backhoe or front shovel, the factors for this equipment were assumed to be half that developed for a bulldozer (Menlove 1991). This reflects the nature of the activities at the site, which would consist primarily of picking up the soil displaced by a bulldozer and dumping it onto a truckbed rather than excavating the soil. Front-end loader activities were assumed to be limited to (1) moving material around piles that have previously been placed (e.g., at the TSA and construction material staging area), (2) operations at the volume reduction facility, and (3) hauling contaminated soil from the TSA to the sludge processing facility for treatment (Section C.3.2.11.) The majority of uncontrolled emissions from front-end loader activity would be generated by vehicle travel over unpaved surfaces. Because no emission factor is available for front-end loader activity, the value identified for unpaved road traffic in Section 11.2.1 of AP-42 was used, in combination with the value for silt content previously identified for site soil. It was assumed that a four-wheel front-end loader would be operated at a speed of 8 km/h (5 mph). Emission factors for scrapers operating in the travel mode are given in Section C.3.2.6.

C.3.2.6 Scraping

Scraping involves removing material from the ground surface and moving it a short haul distance. Scrapers could be used for backfilling the raffinate pits and constructing the disposal cell. The predictive emission factor for scraping in the travel mode was taken from

Section 8.24 of AP-42. The input parameters for this equation include the material silt content (Section C.3.2.1) and mean vehicle weight; the equation used to develop this factor does not take into account the effect of moisture content. To avoid deriving an unreasonable emission factor for site soil having a relatively high moisture content compared with values used in the equations to derive emission factors, the moisture term in the emission factor for bulldozer overburden operations given in Section 8.24 of AP-42 was incorporated into this analysis.

C.3.2.7 Dumping

Dumping includes loading into an end-dump truck, unloading from the truck onto a temporary pile, as appropriate, and unloading into the disposal cell. The emission factor used for aggregate handling and storage piles was taken from Section 11.2.3 of AP-42. These emissions are affected by the moisture content of the material being transferred and the average wind speed. Silt content is an additional factor that would affect emissions from dumping activities at the site, but the standard equation does not include a parameter for this component. Thus, similar to the approach applied for the scraping calculations, a correction term was incorporated for silt content; the value from bulldozer operations for overburden was used for this analysis.

C.3.2.8 Grading

Grading would be conducted to level the material placed in the disposal cell, the backfill and topsoil material placed in restored areas, and the unpaved roads used for various transport activities. The predictive emission factor for grading was taken from Section 8.24 of AP-42. The only variable for this factor is the mean grader speed, for which a value of 8 km/h (5 mph) was used for this analysis (Menlove 1991).

C.3.2.9 Compacting

Grading is typically followed by compacting, which is used to increase the weight per unit volume and the bearing capacity of material in place. An emission factor has not been developed for this activity; therefore, the factor for this activity was assumed to be 50% of that for bulldozers (Menlove 1990).

C.3.2.10 Debris-Related Operations

Debris from the dismantled site structures, building foundations, and equipment would be transported to the volume reduction facility as part of site cleanup activities. The emission factors for related activities were determined from the emission factor equations recommended by the EPA (1988, Section 5.1.2); this guidance addresses mechanical or explosive dismemberment, debris loading, and pushing (bulldozing) operations. The EPA recommends that default values be used whenever possible because information such as silt content and moisture content is generally unavailable for concrete. To minimize fugitive dust emissions, it is expected that,

prior to treatment at the volume reduction facility, concrete building material at the site would be handled in chunks rather than as small particles. The following debris-related operations are addressed in this analysis:

- *Dismantlement:* Dismantlement activities, e.g., for storage or treatment facilities following completion of cleanup activities, were addressed on the basis of information for materials handling operations given in Section 11.2.3 of AP-42; a default material moisture content of 2% was used for this analysis.

- *Debris Loading:* The emission factor for debris loading was determined from two tests in which trucks were filled with crushed limestone by a front-end loader; this is part of the test basis for the batch drop equation presented in Section 11.2.3 of AP-42. The emission factor for this operation is about 10 times higher than that for dismantlement. Because the expected handling of concrete building material differs from the activities for which the emission factors were derived and would be more similar to that associated with dismantling activities, the emission factor for debris loading was assumed to be the same as that for dismantlement.

- *Pushing (Bulldozing) Operations:* The emission factor equations for bulldozing overburden given in Section 8.24 of AP-42 were used for this analysis. Because no values are currently available for the particle size distribution and moisture content of structural debris, default values of 6.9 and 7.9% were used in the equation for silt and moisture content, respectively; these values were taken from Table 8.24-3 of AP-42.

C.3.2.11 Unpaved Road Traffic

Vehicle transport on unpaved roads would involve 8-m^3 (10-yd^3) end-dump trucks, several supply trucks, water trucks, a road grader, and worker/visitor passenger vehicles. In addition, contaminated soil excavated from the raffinate pits and quarry and stored temporarily at the TSA would be transferred by a front-end loader to the sludge processing facility for treatment, and emissions associated with this activity would be similar to those for travel on unpaved roads. The predictive emission factor equation for travel on unpaved roads was taken from Section 11.2.1 of AP-42. This factor is affected by the silt content of the road aggregate, the characteristics of the vehicle (such as vehicle weight, number of wheels, and operating speed), and the number of dry days per year. A four-wheel front-end loader was assumed to be operated at a speed of 8 km/h (5 mph) (Section C.3.2.5). For worker/visitor transport, a nine-passenger vehicle with four wheels and weighing 3 tons was assumed to be operated at an average speed of 40 km/h (25 mph). A 3.5-ton supply truck with six wheels would be used to deliver material such as fuel, lubrication oil, and water to work sites; this vehicle was assumed to be operated at an average speed of 16 km/h (10 mph). A 29-ton tanker truck with 18 wheels, operating at an average speed of 16 km/h (10 mph), would be used to deliver raw materials such as fly ash and cement to the sludge processing facility for chemical treatment. A 10-wheel

water truck weighing 20 tons was assumed to be operated at an average speed of 8 km/h (5 mph) to spray water on unpaved haul routes to control fugitive dust emissions.

C.3.2.12 Uncovered Truckbeds

The emission factor for an uncovered truckbed was taken from EPA guidance (EPA 1989a). Because no measurement is available for this emission source, the EPA conservatively applies the same value developed for an active storage pile. The input parameters in the emission factor equation are the average wind speed and vehicle speed.

C.3.2.13 Wind Erosion from Continuously Active Piles

Active storage piles would be used to store (1) aggregate, sand, and gravel at the construction material staging area and (2) soil excavated from the quarry and the raffinate pits at the TSA. Windblown dust emissions could be generated from these piles and from exposed work areas. The emission factor equation from EPA guidance (EPA 1988, Section 4.1.3) was used to estimate related emissions. Input parameters to this equation include silt content, number of dry days per year, and percentage of time that the unobstructed wind speed exceeds 5.4 m/s (12 mph) at the mean pile height. Contributions resulting from wind erosion were evaluated with a screening-level calculation (Section C.1.3.2).

C.3.3 Source Definition

Each source area associated with site cleanup activities was defined relative to potential fugitive dust generation so that the estimated emission factors could be converted to uncontrolled emission rates. General assumptions for the emission factors are discussed in Section C.1. These source definitions were determined from (1) the optimum daily processing rates of heavy equipment expected to be used, (2) the expected types of equipment and the conceptual scheduling and sequencing of activities, (3) the estimated volumes and densities of material to be handled (Table 2.3), and (4) a conceptual description of the haul routes. Detailed information on these topics is given in the following references: Caterpillar (1989), MK-Environmental Services (1990), Morrison-Knudsen Company (1991), and MK-Ferguson Company and Jacobs Engineering Group (1992).

The emission sources addressed in this analysis can generally be defined in terms of three factors: (1) the total mass of material handled, (2) the total number of activity hours (e.g., for bulldozing), and (3) the total number of vehicle-miles traveled (e.g., by end-dump trucks). For the first factor, the total mass of the material being handled was determined from its estimated volume and density. For the second factor, the average production rate for a given piece of equipment was estimated from the *Caterpillar Performance Handbook* (Caterpillar 1989); the volume of material handled was then divided by this production rate to determine the total number of hours needed for the specific activity. For the third factor, the total vehicle-miles traveled was determined by summing the distances traveled along the appropriate haul routes

for each vehicle involved in the activity. The distances and numbers of trips associated with each activity were estimated on the basis of preliminary engineering information for the site. Projected haul routes that connect the centers of the various source and transfer locations and reasonable haul cycles were developed for the basic cleanup activities (MK-Environmental Services 1990). The number of trips was calculated by dividing the total volume of material to be transported by the capacity of the vehicle (e.g., end-dump truck).

C.3.4 Emission Inventories

The values determined for emission factors and source definitions were used to estimate emission rates, which were then summed to predict a total PM-10 emission rate from which average daily emission rates could be derived. The estimated uncontrolled PM-10 emission inventories for the cleanup activities being considered for the site under Alternative 6a (chemical stabilization/solidification with on-site disposal) are presented in Table C.12; those for Alternative 7a (vitrification with on-site disposal) are presented in Table C.13. Controlled emission inventories were estimated by introducing conventional dust control measures (Section C.3.5); these inventories are also shown in the tables.

Although the contaminated PM-10 emissions for the vitrification alternatives are slightly higher than those for the chemical stabilization/solidification alternative, the total PM-10 emissions — i.e., those from both contaminated and uncontaminated sources — are lower. The difference in the total particulate emissions is due to the smaller volume of the treated product that would require transport for final disposal and the reduced construction effort that would be required for the smaller disposal facility, including lower requirements for borrow soil.

C.3.5 Dust Control Measures

Measures to control fugitive dust emissions were developed to address air quality standards and to identify activities and areas at which controls could be applied to minimize potential exposures of on-site workers and off-site receptors to respirable particulates. The conventional dust control measures expected to be used at the Weldon Spring site during the remedial action period are summarized in Table C.14.

The sludge processing facility would be designed and operated in a manner that would minimize airborne emissions. This could include sealing individual process equipment, enclosing the entire facility, installing air filtration equipment, and maintaining the sludge and soil in a wet condition (e.g., both when transferred to the treatment facility and as the initial product of chemical stabilization/solidification). Estimated control efficiencies for the enclosure of railcar unloading stations, conveyors, and conveyor transfer stations range from 70 to 99% compared with the uncontrolled case, depending on the level of enclosure and whether a bag filter is installed (EPA 1978). On the basis of this information, an average control efficiency of 85% was assumed for an enclosed sludge processing facility.

TABLE C.12 Estimated PM-10 Fugitive Dust Emission Inventories at the Weldon Spring Site for Alternative 6a, Chemical Stabilization/Solidification[a]

Emission Source[b]	Total Uncontrolled Emissions (tons)	Total Controlled Emissions (tons)	Estimated Peak Controlled Emission Rates (lb/d)
Raffinate Pits			
Chemical stabilization/solidification at SPF	31	4.6	12
Excavation[c,d]			
Contaminated soil to be treated	0.78	0.39	8.6
Other soil	1.9	0.92	8.6
Rubble	0.01	0.00[e]	0.7
Dumping or dumping, grading, and compaction			
Contaminated soil at TSA	0.05	0.02	0.5
Other soil at disposal cell	2.3	1.2	11
Truck transport[f]			
Stabilized material (SPF to disposal cell)	45	14	35
Contaminated soil (raffinate pits to TSA)	7.9	2.4	52
Other soil (raffinate pits to disposal cell)	23	7.0	65
Rubble (raffinate pits to MSA debris staging area[g])	0.12	0.04	6.0
Raw material (entry gate to SPF)	12	3.7	9.3
Off-site borrow for backfill (entry gate to raffinate pits)	12	3.6	63
Backfill			
Off-site borrow	2.0	0.98	17
Berm fill	3.1	1.6	75
Miscellaneous transport	6.2	1.9	4.1
Subtotal	150	42	140[h]
Ash Pond			
Soil excavation	0.19	0.09	8.8
Dumping, grading, and compaction at disposal cell	0.24	0.12	11
Truck transport (Ash Pond to disposal cell)	1.7	0.52	48
Miscellaneous transport	0.14	0.04	4.0
Subtotal	2.3	0.77	72
Frog Pond			
Soil excavation	0.04	0.04	5.4
Dumping, grading, and compaction at disposal cell	0.08	0.06	8.2
Truck transport (Frog Pond to disposal cell)	1.2	0.37	53
Miscellaneous transport	0.10	0.03	4.4
Subtotal	1.5	0.49	71
North Dump			
Soil excavation	0.12	0.06	8.8
Dumping at MSA soil staging area	0.01	0.00	0.5
Truck transport (North Dump to MSA soil staging area)	1.4	0.41	61
Miscellaneous transport	0.11	0.03	5.1
Subtotal	1.6	0.50	75

TABLE C.12 (Cont.)

Emission Source[b]	Total Uncontrolled Emissions (tons)	Total Controlled Emissions (tons)	Estimated Peak Controlled Emission Rates (lb/d)
South Dump			
Soil excavation	0.26	0.13	8.8
Dumping, grading, and compaction at disposal cell	0.33	0.16	11
Truck transport (South Dump to disposal cell)	2.3	0.69	46
Miscellaneous transport	0.19	0.06	3.8
Subtotal	3.1	1.0	70
Temporary Storage Area, MSA Soil Staging Area, and Mulch Pile			
Front-end loader activity at TSA[d]			
Contaminated soil for treatment	1.5	0.36	2.3
Building and equipment debris	0.19	0.05	1.3
Excavation			
Miscellaneous soil at TSA	0.17	0.06	8.7
Soil at MSA soil staging area	1.4	0.69	13
Clear and grub material at mulch pile	0.85	0.42	13
Dumping, grading, and compaction at disposal cell			
Miscellaneous soil from TSA	0.12	0.06	8.8
Soil from MSA soil staging area	0.94	0.47	8.8
Clear and grub material from mulch pile	0.58	0.29	8.8
Front-end loader soil transport (TSA to SPF)	3.8	1.1	7.1
Truck transport			
Building and equipment debris (TSA to MSA debris staging area[e])	7.4	2.2	61
Miscellaneous soil (TSA to disposal cell)	1.1	0.33	48
Soil (MSA soil staging area to disposal cell)	6.0	1.8	34
Clear and grub material (mulch pile to disposal cell)	4.4	1.3	39
Miscellaneous transport	2.0	0.59	6.2
Subtotal	30	9.8	74
Busch Lakes 34, 35, and 36			
Excavation	0.80	0.40	27
Dumping, grading, and compaction at disposal cell	0.39	0.20	13
Truck transport (lakes to disposal cell)	11	3.3	260
Grading and reclamation	0.11	0.06	3.8
Miscellaneous transport	0.76	0.24	18
Subtotal	13	4.1	320

TABLE C.12 (Cont.)

Emission Source[b]	Total Uncontrolled Emissions (tons)	Total Controlled Emissions (tons)	Estimated Peak Controlled Emission Rates (lb/d)
Dismantlement of Building, Pipes, and Sewers[i]			
Building dismantlement	1.1	0.57	5.8
Excavation			
Soil beneath buildings	1.2	0.60	22
Soil around pipes and sewers	0.48	0.24	11
Dumping or dumping, grading, and compaction			
Building debris at MSA debris staging area[k]	0.10	0.05	0.5
Soil beneath buildings at MSA soil staging area (Phase I)	0.01	0.01	1.1
Soil beneath buildings at disposal cell (Phases II and III)[l]	0.99	0.49	24
Soil around pipes and sewers at MSA soil staging area	0.02	0.01	0.4
Truck transport			
Building debris (demolition area to MSA debris staging area[k])	4.4	1.3	14
Soil beneath buildings (demolition area to MSA soil staging area) (Phase I)	2.7	0.80	130
Soil beneath buildings (demolition area to disposal cell) (Phases II and III)	5.3	1.6	79
Off-site borrow for backfill (entry gate to demolition area)	17	5.0	110
Soil around pipes and sewers (demolition area to MSA soil staging area)	2.8	0.83	38
Backfill activity			
Off-site borrow for demolition areas	2.1	1.0	24
Nearby soil for pipes and sewers area	0.80	0.40	3.7
Miscellaneous transport	3.7	1.1	4.8
Subtotal	42	14	160
Volume Reduction Facility			
Operation	8.1	0.41	1.0
Dumping and grading at disposal cell	3.0	1.5	3.7
Truck transport (volume reduction facility to disposal cell)	20	6.1	15
Miscellaneous transport	5.5	1.7	4.1
Subtotal	37	9.6	24
Reclamation of Raffinate Pits and Other Excavated Areas			
Backfill activity	3.1	1.5	24
Topsoil emplacement			
Raffinate pits area	0.98	0.49	16
Former chemical plant area	0.72	0.36	16
Truck transport			
Off-site borrow (entry gate to chemical plant area)	27	8.0	120
Topsoil (entry gate to raffinate pits area)	6.7	2.0	64
Topsoil (entry gate to chemical plant area)	6.3	1.9	81
Miscellaneous transport	1.2	0.35	4.8
Subtotal	45	15	250

TABLE C.12 (Cont.)

Emission Source[b]	Total Uncontrolled Emissions (tons)	Total Controlled Emissions (tons)	Estimated Peak Controlled Emission Rates (lb/d)
Disposal Cell Construction and Cell Capping[k]			
Cut and fill operations	3.1	1.5	81
Foundation clay emplacement			
Dumping, grading, and compaction at disposal cell	3.9	2.0	13
Truck transport (entry gate to disposal cell)	42	12	80
Foundation gravel emplacement			
Front-end loader activity at CMSA	2.8	0.70	2.8
Grading and compaction at disposal cell	1.2	0.60	2.3
Truck transport (CMSA to disposal cell)	28	8.3	33
Foundation sand emplacement			
Front-end loader activity at CMSA	0.72	0.19	2.3
Dumping, grading, and compaction at disposal cell	0.44	0.22	2.7
Truck transport (CMSA to disposal cell)	6.9	2.1	25
Clay cover and frost protection layer emplacement			
Dumping, grading, and compaction at disposal cell	9.1	4.5	13
Truck transport (entry gate to disposal cell)	96	29	80
Filter sand layer emplacement			
Front-end loader activity at CMSA	0.95	0.24	2.3
Dumping, grading, and compaction at disposal cell	0.57	0.29	2.7
Truck transport (CMSA to disposal cell)	8.9	2.7	25
Riprap cover emplacement			
Front-end loader activity at CMSA	1.3	0.31	2.5
Grading and compaction at disposal cell	0.59	0.29	2.3
Truck transport (CMSA to disposal cell)	12	3.7	30
Choke rock cover emplacement			
Front-end loader activity at CMSA	0.81	0.21	1.8
Dumping and grading at disposal cell	0.63	0.31	2.7
Truck transport (CMSA to disposal cell)	7.7	2.3	20
Miscellaneous transport	19	5.7	5.9
Subtotal	250	78	310
Total	570	170	850

[a] For the material moved more than once prior to final disposal, emission rates are tabulated separately according to the staged location. For example, contaminated soil surrounding underground sewer lines would be hauled to the MSA soil staging area for temporary storage, with subsequent transport to the disposal cell after it became available. The first segment is included in the "Dismantlement of Buildings, Pipes, and Sewers" category, and the second segment is included in the "Temporary Storage Area, MSA Soil Staging Area, and Mulch Pile" category.

[b] Notation: CMSA = construction material staging area (within the MSA); MSA = material staging area; SPF = sludge processing facility (for chemical treatment under this alternative); TSA = temporary storage area.

[c] Only soil removal is expected to generate particulate emissions at the raffinate pits because the sludge would be dredged and handled wet.

[d] Includes emissions associated with dumping onto the truckbed.

TABLE C.12 (Cont.)

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e Values are listed in this table as "0.00" if emissions are less than 0.005, as a result of rounding.

f Includes emissions from the uncovered truckbed during transport.

g The material would be transported to the MSA debris staging area for treatment at the adjacent volume reduction facility.

h Peak controlled emission rates cannot be directly compared with the sum of individual emission rates because not all activities are expected to occur at the same time.

i These activities are expected to be performed in three phases, as appropriate.

j Soil beneath buildings in the Phase II and III areas would be hauled to and placed in the Phase I cell when it becomes available.

k Cell operations such as waste placement are addressed within the related source category.

TABLE C.13 Estimated PM-10 Fugitive Dust and Stack Emission Inventories at the Weldon Spring Site for Alternative 7a, Vitrification[a]

Emission Source[b]	Total Uncontrolled Emissions (tons)	Total Controlled Emissions (tons)	Estimated Peak Controlled Emission Rates (lb/d)
Raffinate Pits			
Vitrification at SPF	-[c]	0.02	0.1
Front-end loader activity at SPF	1.5	0.23	0.6
Excavation[d,e]			
Contaminated soil to be treated	0.78	0.39	8.6
Other soil	1.9	0.92	8.6
Rubble	0.01	0.00[f]	0.7
Dumping or dumping, grading, and compaction			
Vitrified material mixed with clay at disposal cell	1.5	0.73	2.0
Contaminated soil at TSA	0.05	0.02	0.5
Other soil at disposal cell	2.3	1.2	11
Truck transport[g]			
Vitrified material (SPF to disposal cell)	12	3.5	9.2
Clay for emplacement at disposal cell (entry gate to disposal cell)	2.5	0.74	2.0
Contaminated soil (raffinate pits to TSA)	7.9	2.4	52
Other soil (raffinate pits to disposal cell)	23	6.9	64
Rubble (raffinate pits to MSA debris staging area[h])	0.12	0.04	6.0
Off-site borrow for backfill (entry gate to raffinate pits)	12	3.6	63
Backfill activity			
Off-site borrow	2.0	0.98	17
Berm fill	3.1	1.6	75
Miscellaneous transport	6.2	1.9	4.1
Subtotal	76	25	180[i]
Ash Pond			
Soil excavation	0.19	0.09	8.8
Dumping, grading, and compaction at disposal cell	0.24	0.12	11
Truck transport (Ash Pond to disposal cell)	1.8	0.55	51
Miscellaneous transport	0.15	0.05	4.2
Subtotal	2.4	0.80	75
Frog Pond			
Soil excavation	0.04	0.04	5.4
Dumping, grading, and compaction at disposal cell	0.06	0.06	8.2
Truck transport (Frog Pond to disposal cell)	1.2	0.37	53
Miscellaneous transport	0.10	0.03	4.4
Subtotal	1.5	0.49	71

TABLE C.13 (Cont.)

Emission Source[b]	Total Uncontrolled Emissions (tons)	Total Controlled Emissions (tons)	Estimated Peak Controlled Emission Rates (lb/d)
North Dump			
Soil excavation	0.12	0.06	8.8
Dumping at MSA soil staging area	0.01	0.00	0.5
Truck transport (North Dump to MSA soil staging area)	1.4	0.41	61
Miscellaneous transport	0.11	0.03	5.1
Subtotal	1.6	0.50	75
South Dump			
Soil excavation	0.26	0.13	8.8
Dumping, grading, and compaction at disposal cell	0.33	0.16	11
Truck transport (South Dump to disposal cell)	2.3	0.69	46
Miscellaneous transport	0.19	0.06	3.8
Subtotal	3.1	1.0	70
Temporary Storage Area, MSA Soil Staging Area, and Mulch Pile			
Front-end loader activity at TSA[a]			
Contaminated soil for treatment	1.9	0.47	0.7
Building and equipment debris	0.19	0.05	1.3
Excavation			
Miscellaneous soil at TSA	0.17	0.06	8.7
Soil at MSA soil staging area	2.1	1.1	13
Clear and grub material at mulch pile	0.85	0.42	13
Dumping, grading, and compaction at disposal cell			
Miscellaneous soil from TSA	0.12	0.06	8.8
Soil from MSA soil staging area	1.4	0.72	8.8
Clear and grub material from mulch pile	0.58	0.29	8.8
Front-end loader soil transport (TSA to SPF)	5.4	1.6	2.6
Truck transport			
Building and equipment debris (TSA to MSA debris staging area[b])	7.4	2.2	61
Miscellaneous soil (TSA to disposal cell)	0.84	0.25	37
Soil (MSA soil staging area to disposal cell)	10	3.0	37
Clear and grub material (mulch pile to disposal cell)	4.6	1.4	42
Miscellaneous transport	2.4	0.72	6.2
Subtotal	38	12	74
Busch Lakes 34, 35, and 36			
Excavation	0.80	0.40	27
Dumping, grading, and compaction at disposal cell	0.39	0.20	13
Truck transport (lakes to disposal cell)	11	3.3	260
Grading and reclamation	0.11	0.06	3.8
Miscellaneous transport	0.77	0.24	18
Subtotal	13	4.2	320

TABLE C.13 (Cont.)

Emission Source[b]	Total Uncontrolled Emissions (tons)	Total Controlled Emissions (tons)	Estimated Peak Controlled Emission Rates (lb/d)
Dismantlement of Building, Pipes, and Sewers[j]			
Building dismantlement	1.1	0.57	5.8
Excavation			
Soil beneath buildings	1.2	0.60	22
Soil around pipes and sewers	0.48	0.24	11
Dumping or dumping, grading, and compaction			
Building debris at MSA debris staging area[h]	0.10	0.05	0.5
Soil beneath buildings at MSA soil staging area (Phases I and III)	0.03	0.02	1.1
Soil beneath buildings at disposal cell (Phase II)[k]	0.49	0.25	24
Soil around pipes and sewers at MSA soil staging area	0.02	0.01	0.4
Truck transport			
Building debris (demolition area to MSA debris staging area[h])	4.4	1.3	14
Soil beneath buildings (demolition area to MSA soil staging area) (Phases I and III)	5.6	1.7	130
Soil beneath buildings (demolition area to disposal cell) (Phase II)	2.8	0.83	79
Off-site borrow for backfill (entry gate to demolition area)	17	5.0	110
Soil around pipes and sewers (demolition area to MSA soil staging area)	2.8	0.83	38
Backfill activity			
Off-site borrow for demolition areas	2.1	1.0	24
Nearby soil for pipes and sewers area	0.80	0.40	3.7
Miscellaneous transport	3.7	1.1	4.8
Subtotal	42	14	190
Volume Reduction Facility			
Operation	8.1	0.41	1.0
Dumping and grading at disposal cell	3.5	1.7	4.3
Truck transport (volume reduction facility to disposal cell)	22	6.5	16
Miscellaneous transport	6.0	1.8	4.5
Subtotal	39	10	26
Reclamation of Raffinate Pits and Other Excavated Areas			
Backfill activity	3.1	1.5	24
Topsoil emplacement			
Raffinate pits area	0.98	0.49	16
Former chemical plant area	0.72	0.36	16
Truck transport			
Off-site borrow (entry gate to chemical plant area)	27	8.0	120
Topsoil (entry gate to raffinate pits area)	6.7	2.0	64
Topsoil (entry gate to chemical plant area)	6.3	1.9	81
Miscellaneous transport	1.2	0.35	4.8
Subtotal	45	15	250

TABLE C.13 (Cont.)

Emission Source[b]	Total Uncontrolled Emissions (tons)	Total Controlled Emissions (tons)	Estimated Peak Controlled Emission Rates (lb/d)
Disposal Cell Construction and Cell Capping[d]			
Vitrification Cell			
Cut and fill operations	1.4	0.68	81
Borrow fill emplacement			
Dumping, grading, and compaction at disposal cell	0.72	0.36	13
Truck transport (entry gate to disposal cell)	6.9	2.1	71
Filter sand layer emplacement			
Front-end loader activity at CMSA	0.09	0.02	2.3
Dumping, grading, and compaction at disposal cell	0.05	0.03	2.7
Truck transport (CMSA to disposal cell)	0.74	0.22	22
Clay cover and frost protection layer emplacement			
Dumping, grading, and compaction at disposal cell	1.1	0.56	13
Truck transport (entry gate to disposal cell)	11	3.2	71
Choke rock cover emplacement			
Front-end loader activity at CMSA	0.44	0.11	1.8
Dumping and grading at disposal cell	0.34	0.17	2.7
Truck transport (CMSA to disposal cell)	3.7	1.1	18
Combination Cell			
Cut and fill operations	2.5	1.3	81
Foundation clay emplacement			
Dumping, grading, and compaction at disposal cell	2.9	1.4	13
Truck transport (entry gate to disposal cell)	32	9.6	84
Foundation gravel emplacement			
Front-end loader activity at CMSA	1.0	0.26	2.8
Grading and compaction at disposal cell	0.44	0.22	2.3
Truck transport (CMSA to disposal cell)	11	3.2	35
Foundation sand emplacement			
Front-end loader activity at CMSA	0.53	0.14	2.3
Dumping, grading, and compaction at disposal cell	0.32	0.16	2.7
Truck transport (CMSA to disposal cell)	5.3	1.6	26
Clay cover and frost protection layer emplacement			
Dumping, grading, and compaction at disposal cell	6.7	3.4	13
Truck transport (entry gate to disposal cell)	75	23	84
Filter sand layer emplacement			
Front-end loader activity at CMSA	0.68	0.18	2.3
Dumping, grading, and compaction at disposal cell	0.42	0.20	2.7
Truck transport (CMSA to disposal cell)	6.8	2.0	26
Riprap cover emplacement			
Front-end loader activity at CMSA	0.94	0.24	2.5
Grading and compaction at disposal cell	0.44	0.22	2.3
Truck transport (CMSA to disposal cell)	9.9	3.0	32

TABLE C.13 (Cont.)

Emission Source[b]	Total Uncontrolled Emissions (tons)	Total Controlled Emissions (tons)	Estimated Peak Controlled Emission Rates (lb/d)
Disposal Cell Construction and Cell Capping[j,l] (Cont.)			
Combination Cell (Cont.)			
Choke rock cover emplacement			
Front-end loader activity at CMSA	0.59	0.15	1.8
Dumping and grading at disposal cell	0.46	0.22	2.7
Truck transport (CMSA to disposal cell)	5.9	1.8	21
Miscellaneous transport	19	5.7	5.9
Subtotal	210	66	290
Total	470	150	540

[a] For the material moved more than once prior to final disposal, emission rates are tabulated separately according to the staged location. For example, contaminated soil surrounding underground sewer lines would be hauled to the MSA soil staging area for temporary storage, with subsequent transport to the disposal cell after it became available. The first segment is included in the "Dismantlement of Buildings, Pipes, and Sewers" category, and the second segment is included in the "Temporary Storage Area, MSA Soil Staging Area, and Mulch Pile" category.

[b] Notation: CMSA = construction material staging area (within the MSA); MSA = material staging area; SPF = sludge processing facility (for vitrification under this alternative); TSA = temporary storage area.

[c] Uncontrolled emission rates were not estimated for vitrification operations because emissions would be controlled.

[d] Only soil removal is expected to generate particulate emissions at the raffinate pits because the sludge would be dredged and handled wet.

[e] Includes emissions associated with dumping onto the truckbed.

[f] Values are listed in this table as "0.00" if emissions are less than 0.005, as a result of rounding.

[g] Includes emissions from the uncovered truckbed during transport.

[h] The material would be transported to the MSA debris staging area for treatment at the adjacent volume reduction facility.

[i] Peak controlled emission rates cannot be directly compared with the sum of individual emission rates because not all activities are expected to take place at the same time.

[j] These activities are expected to be performed in three phases, as appropriate (the first and third phases would be conducted concurrently).

[k] Soil beneath buildings in the Phase II area would be hauled to and placed in the Phase I cell when it becomes available.

[l] Cell operations such as waste placement are addressed within the related source category.

TABLE C.14 Dust Control Measures and Estimated Efficiencies[a]

Potential Emission Source	Dust Control Measure	Control Efficiency (%)
Sludge processing facility	Plant enclosure, wet waste form, tight equipment seals, and air filtration equipment	85
Vitrification (stack emissions only)	Off-gas control (e.g., scrubber and HEPA filter)	99.9999
Volume reduction facility	Plant enclosure with baghouse, and water sprays onto contaminated material	95
Excavation, scraping, grading, and compacting	Water spraying with a dedicated truck	50
Front-end loader travel on, around, and between piles at the TSA and MSA, including the CMSA	Application of a petroleum resin/chemical dust suppressant	75
Dumping and loading	Water spraying, including the residual effect of previous spraying	50
Vehicle travel on unpaved roads	Water spraying with a dedicated truck	70
Truckbed or front-end loader (bucket) transport of soil on-site	Water spraying	50
Truckbed transport of soil off-site	Water spraying/tight covering	100
Vehicle travel on paved roads and parking lot[b]	Vacuum sweeping and pressurized water flushing	50
Material stockpiles	Covering (e.g., plastics and tarps)	c

[a] Notation: TSA = temporary storage area; MSA = material staging area; CMSA = construction material staging area; HEPA = high-efficiency-particulate-air (filter).

[b] Emission inventories were not developed for these sources because total emissions would be negligible compared with vehicle traffic on unpaved roads.

[c] See text (Sections C.1.3.2 and C.3.5).

The off-gas treatment system for the vitrification process would be expected to consist of a combination of control devices such as a primary quench scrubber, an acid-gas/submicron aerosol scrubber, and HEPA filters. Most particulate matter generated from the contaminated feed material would be removed while passing through the various control devices. A control efficiency of 99.9999% was assumed for particulate emissions from the vitrification stack; this value was based on information from a literature survey, control efficiencies developed by the EPA, and general engineering information for a vitrification off-gas treatment system developed by Pacific Northwest Laboratory (MK-Ferguson Company and Jacobs Engineering Group 1992).

Volume reduction activities would include shredding and pulverizing rock and structural debris and compacting drummed material. Applicable dust control measures include enclosing the facility; using dust collection hoods and a baghouse at material transfer points; and watering the fine, loose material at the facility. An overall control efficiency of 95% was estimated from the following information given in AP-42 (EPA 1985-1988): (1) a control efficiency of 99% for a fabric filter and (2) a decreased emission factor for TSP of 0.28 lb/ton for dry material to 0.018 lb/ton for wet material.

Use of a dedicated truck for spraying water at areas of active excavation, scraping, grading, and compacting was assumed to provide a dust control efficiency of 50% (much higher efficiencies have been demonstrated, e.g., 70 to 80% and above). Dust emissions associated with front-end loader traffic on, around, and between piles at the TSA and MSA, including the construction material staging area, would be controlled because these piles are expected to be located near the site boundary. Application of a petroleum resin/chemical dust suppressant was assumed to achieve a control efficiency of 75%. For activities such as dumping and loading, a control efficiency of 50% was assumed to account for the residual effect of previous water spraying and/or spraying water at points of dust generation as needed.

Control measures for unpaved haul roads are well documented. The most common and least expensive method of dust control on unpaved roads is water spraying with a dedicated truck, which would require relatively frequent applications to achieve the desired control efficiency (EPA 1988). In this analysis, a 70% average control efficiency was assumed on the basis of a traffic volume of 30 vehicles per hour and an application rate of 0.5 L/m^2 (0.11 gal/yd^2) every 2 hours. A chemical stabilization technique with petroleum resin could also be used if a higher control efficiency were needed, such as for on-site roads where heavy traffic is expected (e.g., those near the site boundary) and for off-site roads leading to the site from borrow areas. A control efficiency of more than 90% could be achieved by this technique, depending on the application intensity (volume of solution applied per surface area), dilution ratio (volume of chemical per volume of water), and application frequency (number of applications per time period).

For emissions from truckbeds loaded with loose material, water spraying was assumed to be the primary control technique for on-site trucks operating over a relatively short distance. Spraying water onto truckbeds and tight sealing for trucks moving between off-site and on-site areas could minimize fugitive dust emissions. Additional dust control could be achieved if the paved roads and the parking lot were routinely cleaned by vacuum sweeping and/or

pressurized water flushing, which would minimize any additive impacts of dust generation associated with both routine use and cleanup activities. In addition, sealed tanker trucks could be used to deliver raw material to the sludge processing facility from off-site suppliers (e.g., for the chemical treatment alternative). Fugitive dust emissions from wind erosion at storage piles and other exposed areas have not been evaluated in detail for this analysis because the stockpiles were assumed to be minimized and winds strong enough to create wind erosion at the site are not expected (Section C.2.2.1). This expectation is supported by results of the screening-level calculation conducted to estimate potential impacts from wind erosion on cumulative air quality. Methods that could be used to control dust from storage piles at the site include covering stockpiles with plastics or tarps and spraying water on exposed, erodible surfaces, especially during dry seasons.

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APPENDIX D:

GROUNDWATER MODELING AND ANALYSIS FOR POTENTIAL DISPOSAL CELL FAILURE

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D.1 INTRODUCTION

Solute transport calculations were performed to evaluate contaminant migration that could potentially occur if the disposal cell failed at each of the three alternative disposal sites for the Weldon Spring waste: the chemical plant area at the Weldon Spring site; the Envirocare facility near Clive, Utah; and the Hanford facility near Richland, Washington. Additional details are presented in a separate report by Tomasko (1992). For this analysis, it was assumed that the cell cover failed, the cell filled with water (e.g., from precipitation), and the liner failed — all without any maintenance activities being conducted.

Although this scenario is unlikely, it was used for this screening-level analysis to provide an upper-bound estimate for the leachate concentration at the initiation of the failure event and to maximize the volume of leachate that could be released to the environment. Other scenarios such as a slow, steady leak from the disposal cell would introduce contaminants to the environment at lower concentrations and smaller volumes over an extended period of time. However, such scenarios would introduce a great deal of uncertainty into the calculations from various factors that include local climate, vegetative cover, and leachate production as a function of time. In addition, the results might not be sufficiently conservative to bound potential impacts because the listed factors could change over the long period of time evaluated for this scenario (e.g., 200 to 1,000 years and beyond); therefore, they were not evaluated in this comparative analysis.

For this study, leachate from a failed cell was assumed to infiltrate the unsaturated zone beneath the point of failure and migrate vertically to the water table. Once the water table was reached, the contaminated water was assumed to mix with water in the phreatic zone and migrate laterally to the location of a hypothetical receptor located at the site boundary. Because of the nature of the problem, precise modeling of the cell-failure scenario would require detailed analyses of leachate production in the cell, a three-dimensional treatment of transport in the unsaturated zone, and a three-dimensional treatment of transport in the saturated zone. Data limitations preclude this level of modeling; therefore, simplifying assumptions were made for this analysis.

To provide a conservative analysis that would be consistent among the alternative disposal sites, a one-dimensional methodology was used to estimate dimensionless contaminant migration (i.e., the concentration of a contaminant divided by the initial contaminant concentration in the leachate). By applying a one-dimensional methodology for the conceptual model, some dispersion phenomena that have the effect of diluting contaminants before they reach receptors (such as lateral mixing perpendicular to groundwater flow in the unsaturated zone) are conservatively disregarded. Transverse dispersion in the saturated zone is accounted for by assuming complete mixing throughout the thickness of the aquifer. This assumption may

not be conservative, but it is not unreasonable because of the length of the flow paths considered for the receptors.

The approach used for this analysis permits a conservative evaluation of the potential consequences of cell failure at each alternative disposal location, given the data limitations. Additional modeling would be conducted during and following conceptual design for the proposed remedial action to incorporate new data and possibly new models to account for factors such as leachate characteristics, multidimensional flow and transport, unsaturated flow directly beneath the point of failure, geochemical interactions during vertical and horizontal contaminant transport, and decay of radioactive contaminants during transport.

The following calculations were performed for each alternative disposal site: (1) a one-dimensional vadose zone calculation to model contaminant transport from the base of the disposal cell to the water table beneath the disposal cell; (2) a dilution calculation to model instantaneous and homogeneous mixing of contaminated, vertically moving water in the vadose zone with initially uncontaminated, horizontally moving groundwater in the aquifer (for purposes of comparison); and (3) a one-dimensional transport calculation to model transport from a point in the aquifer directly below the disposal cell to the location of a specified hypothetical receptor (usually assumed to be the site boundary) in a direction consistent with natural conditions for groundwater flow. To minimize uncertainty in the calculations, as much site-specific information as possible was incorporated into the modeling studies.

The cell was assumed to be of similar design for each site, with a cap designed to last at least 200 years. The calculations were all started from the same initial condition of the waste material in the cell being fully saturated. Waste saturation was assumed to have resulted from localized cap failure, such as cracking, and water was assumed to have subsequently infiltrated into the cell over time and to have been retained by the bottom liner. It was then assumed that the liner failed, releasing the liquid into the underlying soil material and ultimately to groundwater. These assumptions were made for consistency and to ensure a conservative upper bound on the potential adverse consequences of disposal cell failure at each of the three sites.

Climatological differences between the sites were not incorporated in these calculations. However considering differences in annual precipitation, it could take about 3 to 7 times longer to saturate the waste material after the cap failed, e.g., by cracking, at the two western facilities compared with the on-site facility. The annual precipitation at the Envirocare and Hanford facilities is 13 and 25 cm (5 and 10 in.), respectively (U.S. Department of Energy [DOE] 1992c), compared with 86 cm (34 in.) at the Weldon Spring site (DOE 1992b). Evaporation and transpiration were also not considered in the calculations. The effects of these processes on infiltration through disposal cell caps cannot be predicted reliably, but evapotranspirative losses would reduce the fraction of precipitation available for infiltration at all of the sites and would probably have a larger effect at the two western facilities than at the Weldon Spring site, further increasing the time required to saturate the waste cell at those two locations.

The model results are reported as the contaminant travel times to locations that might be accessed by a member of the public and the increases in groundwater contaminant concentrations above background at those locations. Individuals are not expected to access

groundwater at those hypothetical locations, at least under reasonable projections of likely use conditions (recognizing that potential future conditions after 200 to 1,000 years cannot be reliably predicted at this time). However, if it were assumed that such access did occur, differences in the groundwater quality at the three sites might affect the relative likelihood of potential exposures.

Groundwater is currently contaminated at each of the three alternative disposal sites. The contaminants at the Hanford site (e.g., short-lived radionuclides) and the Weldon Spring site (e.g., local contamination with nitroaromatic compounds) would not be evident without a detailed water analysis. In contrast, groundwater at the Envirocare site is naturally high in salinity and dissolved solids content (concentrations in the shallow groundwater are reported as 20,000 to 50,000 mg/L [DOE 1992c]). The salinity of this water would be expected to indicate to a potential receptor its unsuitability for drinking or other domestic uses. In addition, over the long period of time (hundreds to thousands of years) before contaminants from a cell failure scenario would reach the hypothetical receptor locations, the current groundwater contamination at the Weldon Spring and Hanford sites would likely be ameliorated by processes not accounted for in the current model, such as radioactive decay, chemical and biological alteration, and dilution. However, the high dissolved solids content in groundwater at the Envirocare site is a natural condition that would not be expected to change over time. Thus, assuming that an individual would be exposed to groundwater at the Envirocare facility is conservative.

The results of the calculations for this analysis provide conservative estimates of (1) the approximate times, after failure of the bottom liner, for dissolved contaminants to move from each disposal cell to the locations of hypothetical receptors and achieve a maximum concentration and (2) the maximum dimensionless contaminant concentrations (C/C_0) at the receptors as a function of time (Tomasko 1992). Because the composition and concentration of various contaminants in the leachate from the proposed disposal cell are not precisely defined, the calculations use retardation factors of 1, 5, and 100 — which provide a range of solute retardation values from highly mobile to relatively immobile species. This range of retardation is expected to bracket the anticipated behavior of contaminant components in the leachate that could be generated in the disposal cell (e.g., under conditions of cover failure without maintenance). Dimensional concentrations at the receptors can be obtained by multiplying the predicted dimensionless concentrations by the initial concentrations of the leachate.

D.2 METHODOLOGY

The processes modeled in evaluating the concentration of a contaminant at a downstream receptor in the event of disposal cell failure are illustrated in Figure D.1. Leachate released from a failed disposal cell would be transported vertically downward through the unsaturated (vadose) zone directly beneath the disposal cell footprint. At some depth from the ground surface, the contaminated water would reach the water table. At this point, the vertically moving contaminated groundwater in the vadose zone would mix with the horizontally moving groundwater in the aquifer. Upon entering the unconfined aquifer, the contaminants would be laterally transported by natural groundwater flow to the location of the receptor. For modeling

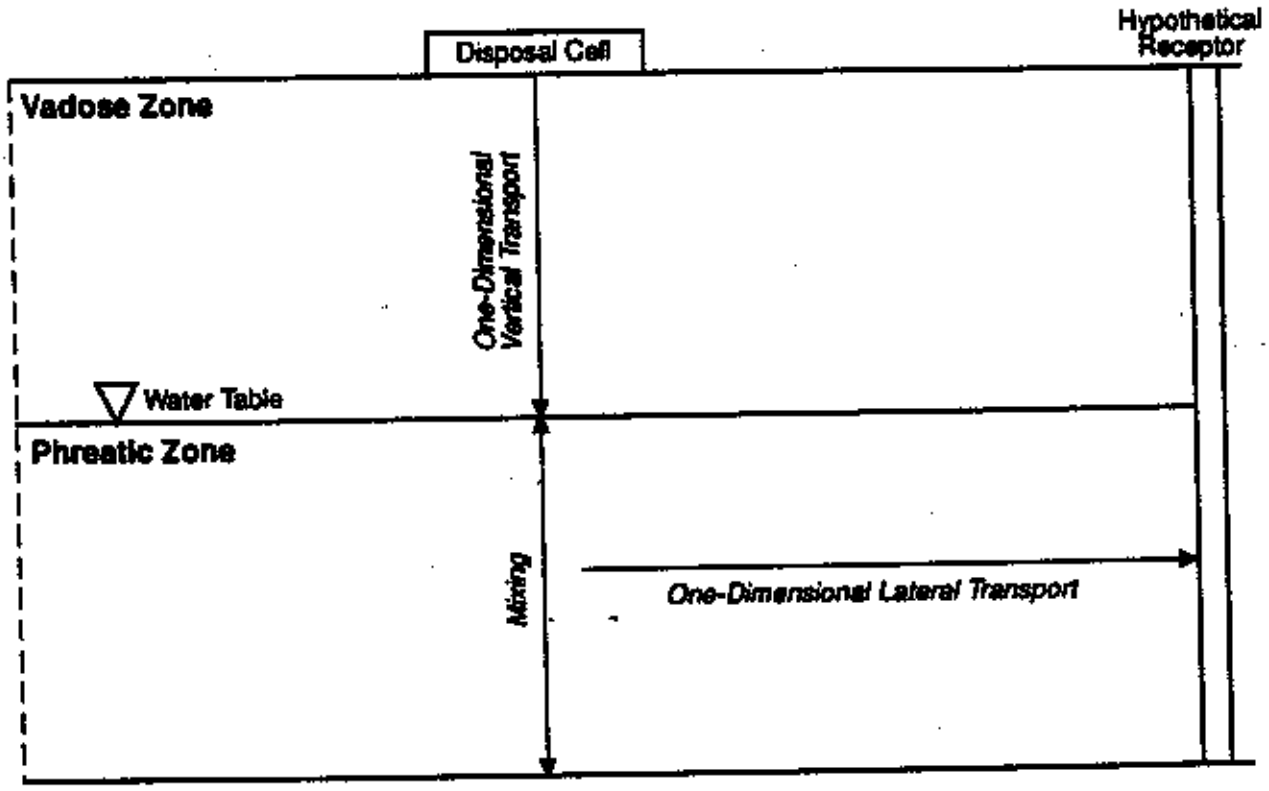

FIGURE D.1 Fate and Transport Processes Modeled for Disposal Cell Failure

purposes, the physical processes shown in Figure D.1 were simplified to two one-dimensional transport calculations (vadose and phreatic zones) and one dilution calculation at the water-table interface (Tomasko 1992).

D.3 GOVERNING EQUATIONS

In the vadose zone, one-dimensional solute transport was calculated with the following equation (Tomasko 1992):

$$\frac{C}{C_0} = \frac{1}{2}\left[\text{ERFC}\left(\frac{ZR - Vt}{2\sqrt{DRt}}\right) + e^{VZ/D}\ \text{ERFC}\left(\frac{ZR + Vt}{2\sqrt{DRt}}\right)\right] \qquad \text{(D.1)}$$

$$- \frac{1}{2}\,H(t - \Delta t)\left[\text{ERFC}\left(\frac{ZR - V(t - \Delta t)}{2\sqrt{DR(t - \Delta t)}}\right) + e^{VZ/D}\ \text{ERFC}\left(\frac{ZR + V(t - \Delta t)}{2\sqrt{DR(t - \Delta t)}}\right)\right]$$

where:

C = contaminant concentration (M/L^3);

C_0 = contaminant concentration in the leachate (M/L^3);

ERFC = complementary error function;

Z = spatial coordinate in the vertical direction (L);

R = retardation coefficient;

V = groundwater seepage velocity (L/t);

t = time (t);

D = dispersion coefficient (L^2/t);

H = Heaviside function such that $H(t - \Delta t) = 0$ for $t < \Delta t$, and $H(t - \Delta t) = 1$ for $t \geq \Delta t$; and

Δt = duration of the leachate percolation (t).

(Units are represented by generic terms for mass, length, and time [M, L, and t].)

At the water table, contaminated water in the vadose zone is assumed to mix with initially uncontaminated water in the unconfined aquifer beneath the disposal cell (to simplify the determination of potential incremental impacts to groundwater quality). The ratio of the contaminant concentrations in the unsaturated zone to those in the saturated zone can be defined as the dilution for the process, D_1. This dilution can be expressed by the following relationship (U.S. Environmental Protection Agency 1989):

$$D_1 = \frac{Q_h + Q_v}{Q_v} \qquad \text{(D.2)}$$

where:

Q_h = volumetric flux in the horizontal direction in the phreatic zone; and

Q_v = volumetric flux in the vertical direction in the vadose zone.

As discussed by Tomasko (1992), Equation D.2 can be rewritten as:

$$D_1 = \frac{V_d T}{I X_1 \Phi_v} + 1 \qquad (D.3)$$

where:

V_d = Darcy velocity as $V_d = K \nabla h$, where K = hydraulic conductivity (L/t) and ∇ = hydraulic gradient (1/L);

T = thickness of the saturated zone (L);

I = infiltration rate (L/t);

X_1 = length of the disposal cell parallel to the direction of groundwater flow (L); and

Φ_v = effective porosity of the vadose zone (L^3/L^3).

Once in the unconfined aquifer, the contaminant is assumed to be transported laterally to the location of the hypothetical downgradient receptor. Transport is once again assumed to be governed by a one-dimensional advection-dispersion process. The contaminant concentration at some downstream location, X, is calculated with Equation D.1 — after replacing Z with X and Δt with $\Delta t_{1/2}$, the full width of the breakthrough curve at the water table at the half-maximum concentration value (Tomasko 1992).

D.4 CONTAMINANT TRANSPORT CALCULATIONS

Three sets of calculations were performed for each of the alternative disposal sites to evaluate the transport of contaminants from the bottom of the disposal cell to potential receptors. The first set of calculations was performed to evaluate vertical contaminant migration through the vadose zone, the second set was used to define dilution factors, and the third set was used to evaluate lateral contaminant migration to the location of a potential receptor.

D.4.1 Weldon Spring Site

The vadose zone in the vicinity of the disposal cell location evaluated for the chemical plant area is about 15 m (50 ft) thick (MK-Ferguson Company and Jacobs Engineering Group 1990; DOE 1992b). The overburden consists of five layers: topsoil and loess, Ferrelview clay, clay till, basal till, and residuum. An effective overburden model developed from laboratory measurements indicates that the harmonic mean saturated hydraulic conductivity of the overburden is about 3.1×10^{-6} cm/s (8.8×10^{-5} ft/d) for a 6-m (20-ft) thick overburden (Bognar 1991). For purposes of this study, it was assumed that the overburden thickness is 9 m (30 ft) and that the saturated hydraulic conductivity is 1.0×10^{-7} cm/s (2.8×10^{-4} ft/d). These values

were chosen to produce conservative results; to represent subsurface conditions that would be engineered (e.g., via compaction) as part of cell construction; and to be consistent with Missouri state law, which requires a minimum of 9 m (30 ft) of overburden having a conductivity of, at most, 1.0×10^{-7} cm/s (2.8×10^{-4} ft/d). For conservative results, transport through the composite overburden material was assumed to occur under saturated conditions with the infiltration rate equal to the harmonic mean hydraulic conductivity (Freeze and Cherry 1979). Dispersivity was assumed to be scale dependent (Lallemand-Barrès and Peaudecerf 1978) and was set to 1 m (3 ft), one-tenth of the average thickness of the overburden.

The results of dimensionless concentration calculations obtained using Equation D.1 for the vadose zone at the Weldon Spring site are shown in Figures D.2 and D.3 for retardation values of 1, 5, and 100. The value of 1 was selected to represent a purely conservative solute (i.e., no retardation), such as nitrate. The value of 5 was chosen to represent contaminants that are relatively mobile in porous media, such as selenium. The retardation factor of 100 was chosen to represent relatively immobile species, such as lead, nickel, and thorium (see Appendix E, Section E.3.2). For all calculations involving the Weldon Spring site, the disposal cell was assumed to discharge its full liquid contents to the underlying overburden in 150 years. This value is based on a disposal cell having a height of 23 m (75 ft), an effective porosity of 0.2, and an infiltration velocity of 1.0×10^{-7} cm/s (2.8×10^{-4} ft/d).

For unretarded contaminants (Figure D.2), contaminant concentrations in groundwater at the interface of the unsaturated and saturated zones would reach a maximum value of about 52% of their initial concentration in the disposal cell leachate in about 300 years. Moderately retarded contaminants would reach a maximum concentration of about 12% in 1,160 years, and highly retarded contaminants (Figure D.3) would reach a maximum concentration of about 0.6% in about 22,000 years.

Once the contaminated water in the unsaturated zone reached the water table, mixing would occur with groundwater that was assumed to be initially uncontaminated for purposes of comparison. Mixing was assumed to occur instantaneously and homogeneously throughout the thickness of the saturated zone. Equation D.3 was used to assess the effects of dilution for the Weldon Spring site. Site-specific parameters used in this evaluation include an arbitrary disposal cell failure length of 60 m (200 ft), parallel to the direction of groundwater flow; an unsaturated zone effective porosity of 0.3; a saturated thickness of 8 m (25 ft); a saturated zone effective porosity of 0.2; a hydraulic gradient in the vicinity of the chemical plant area of 0.02; and a hydraulic conductivity value of about 0.0044 cm/s (12.5 ft/d) (Bechtel National 1987). For an infiltration rate equal to the harmonic mean saturated hydraulic conductivity of the composite overburden material, 1.0×10^{-7} cm/s (1.2 in./yr), the dilution factor is about 380.

Once the contaminants have mixed with groundwater in the saturated zone, migration to the location of the receptor is assumed to follow natural flow lines, which are predominantly horizontal and to the north (DOE 1992a). For the Weldon Spring site, three receptor locations were considered. The first receptor was assumed to be located at the site boundary; the downstream distance from the location of the proposed disposal cell to the site boundary would

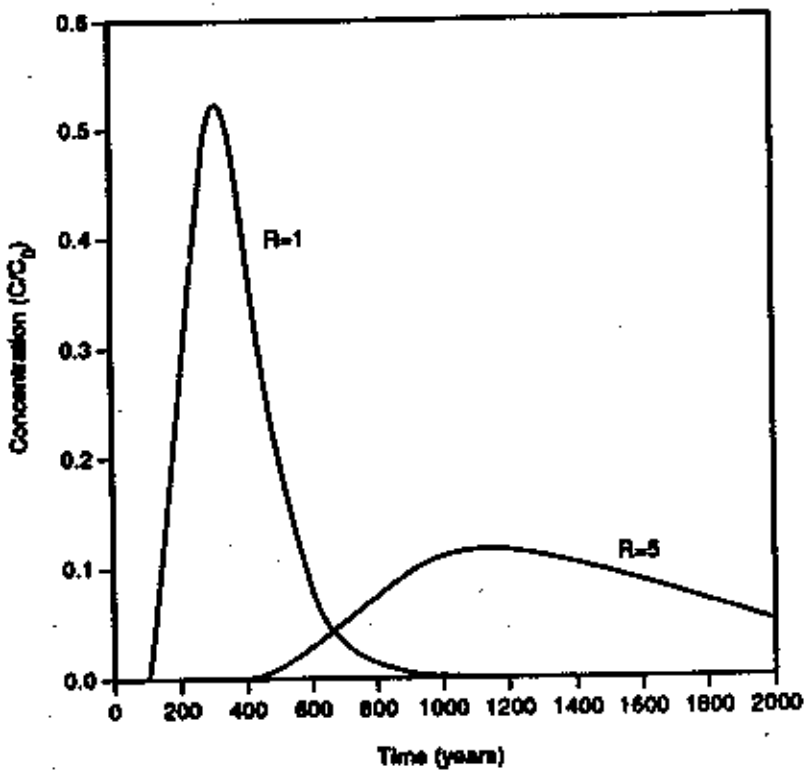

FIGURE D.2 Contaminant Breakthrough Curves for the Vadose Zone at the Weldon Spring Site: Retardation = 1 and 5

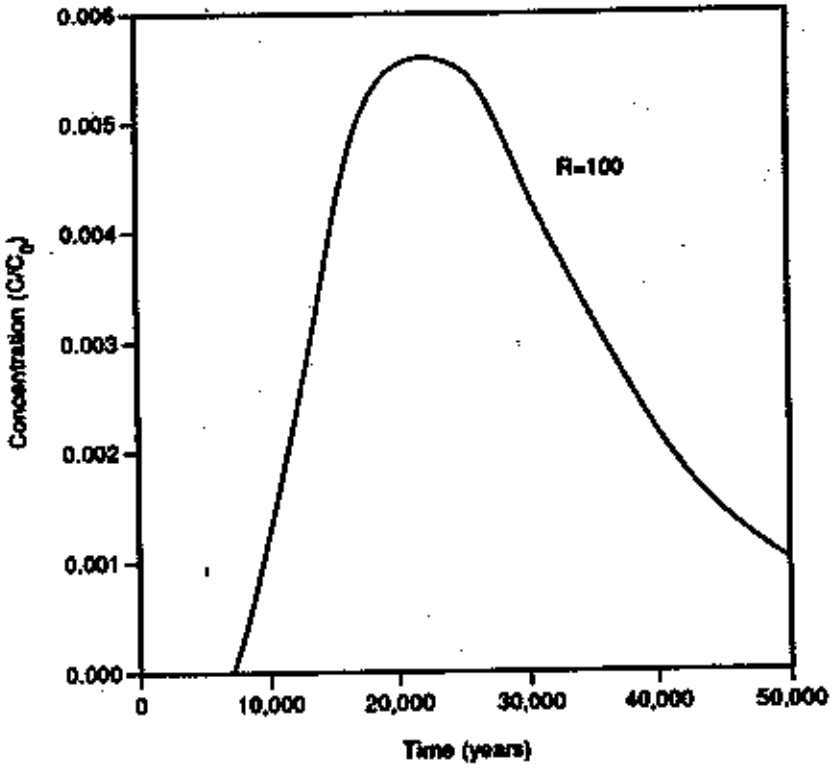

FIGURE D.3 Contaminant Breakthrough Curves for the Vadose Zone at the Weldon Spring Site: Retardation = 100

be about 300 m (1,000 ft). A second receptor was assumed to be located at the next closest downgradient well used for drinking water, about 2.4 km (1.5 mi) north of the disposal cell. A third receptor was assumed to be located 4.0 km (2.5 mi) north of the disposal cell, which corresponds with the downgradient location of additional private wells. For these three receptor locations, the unconfined aquifer was assumed to be laterally homogeneous, with a hydraulic gradient of about 0.02, an effective porosity of 0.2 (Freeze and Cherry 1979), and an average hydraulic conductivity of 0.0044 cm/s (12.5 ft/d). For these conditions, the average linear groundwater velocity (Darcy velocity divided by effective porosity) in the phreatic zone is about 0.38 m/d (1.25 ft/d). Dispersivity was assumed to be 30 m (100 ft) for all locations. The results of the saturated transport calculations are shown in Figures D.2 and D.3; the full widths of the contaminant pulses at the interface at the half-maximum concentration values are estimated to be 260, 1,160, and 23,500 years for retardation values of 1, 5, and 100, respectively.

The results for a receptor located at a downstream distance of 300 m (1,000 ft) are shown in Figures D.4 and D.5. Contaminants would reach a maximum concentration of 100% of their initial value (peak value of the unsaturated breakthrough curve at the interface of the vadose and phreatic zones divided by the dilution factor) in about 12, 58, and 540 years for retardation values of 1, 5, and 100, respectively.

Breakthrough curves at 2.4 km (1.5 mi) and 4.0 km (2.5 mi) would be similar to those shown in Figures D.4 and D.5. At 2.4 km (1.5 mi) from the disposal cell, the contaminants would reach concentrations of 100% of their initial values in 36, 172, and 3,400 years for retardations of 1, 5, and 100, respectively. For a receptor at a distance of 4.0 km (2.5 mi), the contaminants would reach 100% of their initial concentrations in about 52, 248, and 4,950 years for retardations of 1, 5, and 100, respectively. Reaching 100% of the initial concentration is expected for these calculations because of the high hydraulic conductivity assumed for the porous medium and the long durations of the assumed sources. Because a square-wave source was assumed at the water table, the peak concentration at the receptor could be reached before a peak concentration was attained at the water table directly below the disposal cell (Tomasko 1992). This result provides a conservative estimate of the time required to reach the maximum concentration at the receptor.

The results of the three separate calculations (overburden, dilution, and saturated lateral flow) were combined to obtain values for the entire flow system — i.e., from the top of the overburden to potential receptor locations 300 m (1,000 ft), 2.4 km (1.5 mi), and 4.0 km (2.5 mi) downgradient of the hypothetical disposal cell (Tomasko 1992); these results are presented in Table D.1.

D.4.2 Envirocare Facility near Clive, Utah

The vadose zone in the vicinity of the disposal cell site evaluated for the Envirocare facility near Clive, Utah, is about 6 m (18 ft) thick (Bingham Environmental 1991). This unsaturated overburden is composed of two layers: 2.5 m (8 ft) of clay and 3 m (10 ft) of silty sand. The clay has an average saturated hydraulic conductivity of about 1.9×10^{-7} cm/s

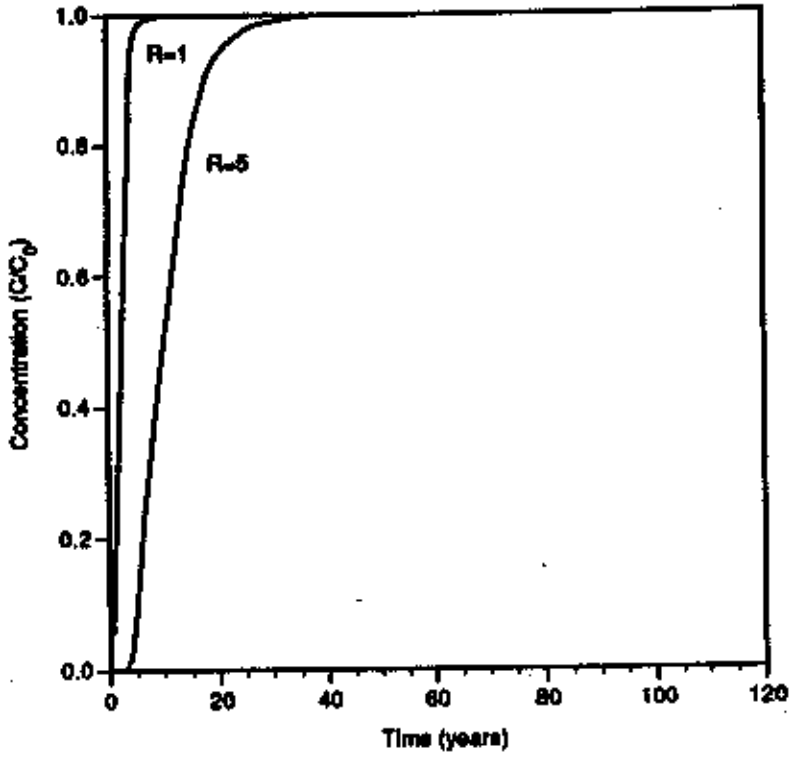

FIGURE D.4 Contaminant Breakthrough Curves for the Phreatic Zone at the Weldon Spring Site: Retardation = 1 and 5; Distance to Receptor = 1,000 ft

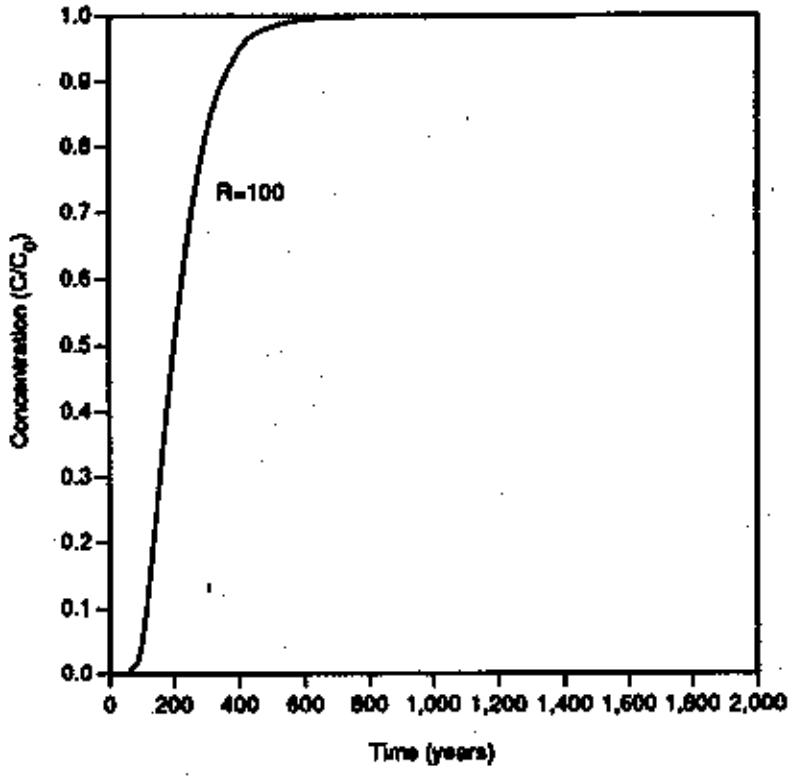

FIGURE D.5 Contaminant Breakthrough Curves for the Phreatic Zone at the Weldon Spring Site: Retardation = 100; Distance to Receptor = 1,000 ft

TABLE D.1 Summary of Disposal Cell Failure Calculations for the Weldon Spring Site: Entire Flow System[a]

	Maximum Concentration at Location of Receptor (percent of initial concentration)			Time of Maximum Concentration at Location of Receptor (years)		
Retardation	1,000 ft	1.5 mi	2.5 mi	1,000 ft	1.5 mi	2.5 mi
1	0.14	0.14	0.14	212	236	252
5	0.032	0.032	0.032	788	902	978
100	1.6×10^{-3}	1.6×10^{-3}	1.6×10^{-3}	13,540	16,400	17,950

[a] These calculations are the combined results of three separate calculations: the vertical component through the vadose (unsaturated) zone, dilution, and the lateral flow component through the phreatic (saturated) zone.

(5.4×10^{-4} ft/d), and the silty sand has a conductivity of about 5.6×10^{-5} cm/s (0.16 ft/d). An equivalent composite overburden was assumed for the vadose zone calculations. This composite material has a thickness of 5.5 m (18 ft) and an equivalent, harmonic mean saturated hydraulic conductivity of 4.3×10^{-7} cm/s (0.0012 ft/d). Infiltration of the leachate from the disposal cell was conservatively assumed to occur under saturated conditions, with an average linear groundwater velocity equal to the harmonic average of the saturated hydraulic conductivity of the composite overburden. The rate of contaminant infiltration below an equivalent disposal cell at the Envirocare facility would be approximately 4.3 times faster than that at the Weldon Spring site because of the higher saturated hydraulic conductivity material beneath the Envirocare area. A saturated disposal cell at Envirocare would empty its leachate contents in about 35 years following cell failure. Dispersivity was assumed to be scale dependent (Lallemand-Barrès and Peaudecerf 1978) and was set to 0.5 m (1.8 ft), one-tenth of the average thickness of the composite material. The results of dimensionless contaminant concentration calculations for the vadose zone are summarized in Table D.2.

Once the contaminated water in the unsaturated zone has reached the water table, mixing would occur with groundwater assumed to be initially uncontaminated. Mixing was assumed to occur instantaneously and homogeneously throughout the thickness of the saturated zone. Equation D.3 was used to assess the effects of dilution for the Envirocare facility. Site-specific parameters used in this evaluation include an arbitrary disposal cell failure length of 60 m (200 ft), parallel to the direction of groundwater flow; an unsaturated zone effective porosity of 0.3; a saturated thickness of 13 m (42 ft); a saturated zone effective porosity of 0.2; and a groundwater velocity of 7 m/yr (23 ft/yr) in the saturated zone (Bingham Environmental 1991). For an infiltration rate equal to the saturated hydraulic conductivity of the composite overburden, 4.3×10^{-7} cm/s (5 in./yr), the dilution factor is about 8.2.

TABLE D.2 Summary of Disposal Cell Failure Calculations for the Envirocare Facility: One-Dimensional Vadose Zone[a]

Retardation	Maximum Concentration at Bottom of Unsaturated Zone (percent of initial concentration)	Time of Maximum Concentration at Bottom of Unsaturated Zone (years)	Duration at Half-Maximum (years)
1	75	55	42
5	19	170	160
100	1	3,050	3,300

[a] These calculations include only the vertical flow component through the vadose (unsaturated) zone.

Once the contaminants have mixed with the groundwater in the saturated zone, migration to the location of the receptor would follow natural flow lines, which are predominantly horizontal and to the north (Bingham Environmental 1991). One hypothetical receptor was considered for the Envirocare facility. This receptor was assumed to be located at the site boundary, approximately 1,600 m (5,280 ft) from the assumed location of the disposal cell.

The average linear groundwater velocity (Darcy velocity divided by effective porosity) in the unconfined uppermost groundwater aquifer at the Envirocare facility is about 0.019 m/d (0.062 ft/d). A scale-dependent dispersivity (Lallemand-Barrès and Peaudecerf 1978) was assumed for the lateral transport calculations; a dispersivity value of 31 m (100 ft) (Freeze and Cherry 1979) was used to produce conservative breakthrough concentration curves. The results for a receptor located at a distance of 1,600 m (5,280 ft) from the disposal cell are given in Table D.3.

The results of the three separate calculations (overburden, dilution, and saturated lateral flow) were combined to obtain values for the entire flow system — i.e., from the top of the overburden to a potential receptor 1,600 m (5,280 ft) downgradient of the hypothetical disposal cell (Tomasko 1992); the results are presented in Table D.4.

D.4.3 Hanford Facility near Richland, Washington

The vadose zone in the vicinity of the disposal cell site evaluated at the Hanford facility (i.e., the 200-West Area) near Richland, Washington, is about 30 m (100 ft) thick (Pacific Northwest Laboratory 1989). It is composed of a series of sands, gravels, and silts. The average saturated hydraulic conductivity of the unsaturated zone is about 75 m/d (250 ft/d). Infiltration

TABLE D.3 Summary of Disposal Cell Failure Calculations for the Envirocare Facility: One-Dimensional Phreatic Zone[a]

Retardation	Maximum Concentration at Location of Receptor[b] (percent of initial concentration)	Time of Maximum Concentration at Location of Receptor[b] (years)
1	38	240
5	29	1,160
100	30	23,500

[a] These calculations include only the lateral flow component through the phreatic (saturated) zone.

[b] The receptor was assumed to be located 5,280 ft from the disposal cell.

TABLE D.4 Summary of Disposal Cell Failure Calculations for the Envirocare Facility: Entire Flow System[a]

Retardation	Maximum Concentration at Location of Receptor[b] (percent of initial concentration)	Time of Maximum Concentration at Location of Receptor[b] (years)
1	3.3	272
5	0.62	1,270
100	0.033	25,360

[a] These calculations are the combined results of three separate calculations: the vertical flow component through the vadose (unsaturated) zone, dilution, and the lateral flow component through the phreatic (saturated) zone.

[b] The receptor was assumed to be located 5,280 ft from the disposal cell.

of the leachate from the disposal cell was conservatively assumed to occur under saturated conditions (the volume of leachate was assumed to be sufficient to saturate a vertical column from the bottom of the disposal cell to the water table), with an average linear groundwater velocity equal to the value of the saturated hydraulic conductivity. Because of the highly transmissive sands and gravels beneath the footprint of an equivalent disposal cell at Hanford, the leachate emptying time following cell failure was 1.7×10^{-4} years compared with 150 years at the Weldon Spring site. Although the high value of the saturated hydraulic conductivity results in an extremely short and overly conservative emptying time, this value was used to ensure a consistent approach to bounding the consequences of disposal cell failure at each of the alternative disposal sites. As with the other two sites, dispersivity was assumed to be scale dependent (Lallemand-Barrès and Peaudecerf 1978) and was set equal to 3 m (10 ft), one-tenth of the average thickness of the vadose zone. The results of dimensionless contaminant concentration calculations for the vadose zone are summarized in Table D.5.

Once the contaminated water in the unsaturated zone has reached the water table, mixing would occur with groundwater assumed to be initially uncontaminated. Mixing was assumed to occur instantaneously and homogeneously throughout the thickness of the saturated zone. Equation D.3 was used to assess the effects of dilution for the Hanford 200-West Area. Site-specific parameters used in this evaluation include an arbitrary disposal cell failure length of 60 m (200 ft), parallel to the direction of groundwater flow; an unsaturated zone effective porosity of 0.3; a saturated thickness of 60 m (200 ft); a saturated zone effective porosity of 0.2; and a groundwater velocity of 1,100 m/yr (3,650 ft/yr) in the saturated zone (Pacific Northwest Laboratory 1989). The results of the dilution calculations indicate that, for an infiltration rate of 0.09 cm/s (250 ft/d), the dilution factor would be about 1.0 — i.e., there is no dilution.

Once the contaminants have mixed with the groundwater in the saturated zone, migration to the location of the receptor is assumed to follow natural flow lines, which are

TABLE D.5 Summary of Disposal Cell Failure Calculations for the Hanford 200-West Area: One-Dimensional Vadose Zone[a]

Retardation	Maximum Concentration at Bottom of Unsaturated Zone (percent of initial concentration)	Time of Maximum Concentration at Bottom of Unsaturated Zone (years)	Duration at Half-Maximum (years)
1	17	9.0×10^{-4}	9.5×10^{-4}
5	3.5	4.2×10^{-3}	4.5×10^{-3}
100	0.17	0.08	0.09

[a] These calculations include only the vertical flow component through the vadose (unsaturated) zone.

predominantly horizontal and to the northeast (Pacific Northwest Laboratory 1989). One hypothetical receptor was considered for Hanford. This receptor was assumed to be located at the site boundary approximately 13.7 km (44,800 ft) from the 200-West Area.

The average linear groundwater velocity (Darcy velocity divided by effective porosity) in the Hanford Formation is about 1,100 m/yr (3,650 ft/yr). A scale-dependent dispersivity (Lallemand-Barrès and Peaudecerf 1978) was assumed for the lateral transport calculations; a dispersivity value of 31 m (100 ft) (Freeze and Cherry 1979) was used to calculate conservative breakthrough concentration curves. Results of the calculations are given in Table D.6.

The results of the three separate calculations (overburden, dilution, and saturated lateral flow) were combined to obtain values for the entire flow system — i.e., from the top of the overburden to the potential receptor 13.7 km (44,800 ft) downgradient of the hypothetical disposal cell (Tomasko 1992); the results are presented in Table D.7.

D.5 COMPARISON OF ALTERNATIVE DISPOSAL LOCATIONS

Peak contaminant breakthrough concentrations and times calculated for the three disposal sites were compared to assess relative hydrological impacts. For greatest utility, comparisons were made at the bottom of the overburden (location of the water table) and at the location of the receptor. A summary of physical parameters is given in Table D.8.

The maximum contaminant concentrations reached at the water table as a function of retardation for the three alternative disposal sites are compared in Figure D.6. From this simplified analysis, the lowest peak concentration would occur at the Hanford facility and the highest at the Envirocare facility. Concentrations at the Weldon Spring site and the Envirocare facility would be similar. Those for the Hanford facility would be low because of dispersion along the vertical flow path. At small retardation values, the differences between the peak concentrations for the sites is large; however, at large retardation values, the differences become small as the concentrations approach zero.

Breakthrough times for the maximum concentrations at the water table are compared in Figure D.7. Because of the clays present in the overburden material at the Weldon Spring site and Envirocare facility, breakthrough times would be long. The breakthrough time at the Weldon Spring site would be longest because of the assumed thickness of the overburden and its assumed low saturated hydraulic conductivity. Breakthrough times at the Hanford facility, on the other hand, would be very short because of the high hydraulic conductivity of the sands and gravels in the overburden. As expected, the time of peak breakthrough increases with increasing retardation.

The maximum contaminant concentrations at the receptor locations are compared in Figure D.8. The maximum concentrations would be largest for the Envirocare facility and smallest for the Weldon Spring site. In all cases, peak concentrations at the receptor are less than about 3% of the initial leachate value. Except for cases of high initial leachate concentrations or

TABLE D.6 Summary of Disposal Cell Failure Calculations for the Hanford 200-West Area: One-Dimensional Phreatic Zone[a]

Retardation	Maximum Concentration at Location of Receptor[b] (percent of initial concentration)	Time of Maximum Concentration at Location of Receptor[b] (years)
1	0.045	12
5	0.044	61
100	0.044	1,220

[a] These calculations include only the lateral flow component through the phreatic (saturated) zone.

[b] The receptor was assumed to be located 44,800 ft from the disposal cell.

TABLE D.7 Summary of Disposal Cell Failure Calculations for the Hanford 200-West Area: Entire Flow System[a]

Retardation	Maximum Concentration at Location of Receptor[b] (percent of initial concentration)	Time of Maximum Concentration at Location of Receptor[b] (years)
1	7.7×10^{-3}	12
5	1.5×10^{-3}	61
100	7.6×10^{-5}	1,220

[a] These calculations are the combined results of three separate calculations: the vertical flow component through the vadose (unsaturated) zone, dilution, and the lateral flow component through the phreatic (saturated) zone.

[b] The receptor was assumed to be located 44,800 ft from the disposal cell.

TABLE D.8 Summary of Physical Parameters for Calculations

Zone/Parameter	Unit[a]	Weldon Spring Site	Envirocare Facility	Hanford Facility
Vadose Zone				
Thickness	m	9	5.5	30
Infiltration	cm/s	1.0×10^{-7}	4.3×10^{7}	0.09
Duration	yr	150	35	1.7×10^{-4}
Effective porosity	-	0.3	0.3	0.3
Dispersivity	m	1	0.5	3
Phreatic Zone				
Thickness	m	8	13	60
Effective porosity	-	0.2	0.2	0.2
Hydraulic conductivity	cm/s	0.0044	0.015	0.088
Distance to receptor	mi	0.2, 1.5, or 2.5	1.0	8.5
Dispersivity	m	30	30	30
Hydraulic gradient	-	0.02	0.0003	0.008

[a] A hyphen indicates that the parameter is dimensionless (unitless).

high contaminant toxicities, disposal cell failure would not have a significant effect on water quality at the receptor location for any of the sites.

Breakthrough times for the maximum concentrations at the receptor locations are compared in Figure D.9; these times follow the same general trends discussed for breakthrough times at the water table. The breakthrough times for the Weldon Spring site and Envirocare facility are similar because of their similar phreatic zone properties (Table D.8). In spite of the large distance to the receptor location at Hanford (13.7 km [44,800 ft]), travel times would be much less than those of the other two sites because of the very high hydraulic conductivity of the sands and gravels present.

For all three sites, a disposal cell failure would not be expected to have a significant effect on water quality at the hypothetical receptor locations. The conservative nature of the one-dimensional methodology used and the simplifying assumptions made for this comparative analysis provide upper bounds on the potential impacts. If extensive site-specific data had been available to support the use of a more detailed modeling approach, it is likely that the facilities at the two western sites, i.e., the Hanford and Envirocare facilities, would exhibit longer breakthrough times and lower peak concentrations at the receptors than those estimated for this screening-level analysis.

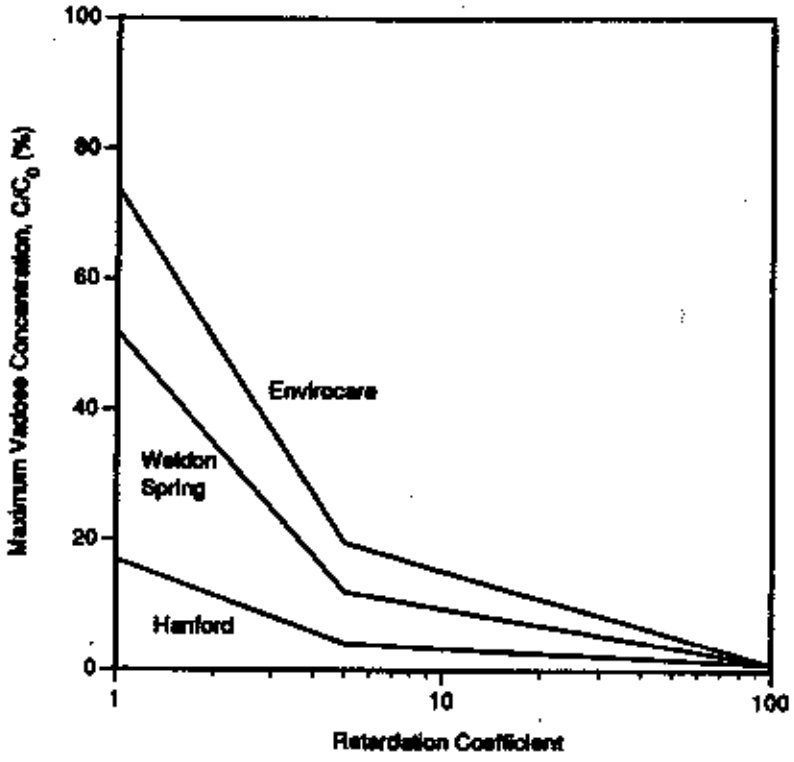

FIGURE D.6 Comparison of Maximum Breakthrough Concentrations for the Vadose Zone at the Alternative Disposal Sites

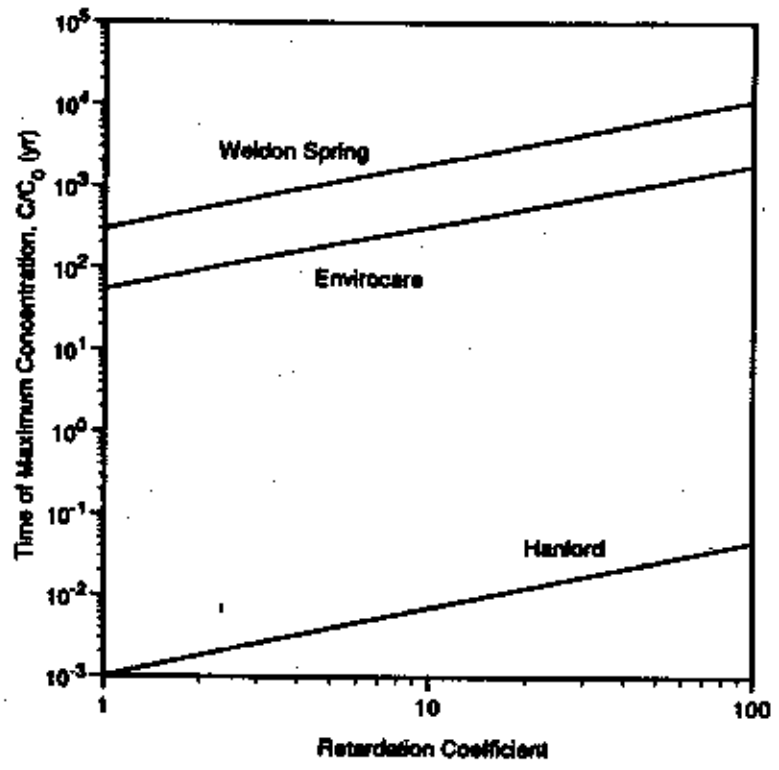

FIGURE D.7 Comparison of the Times of Maximum Breakthrough Concentrations for the Vadose Zone at the Alternative Disposal Sites

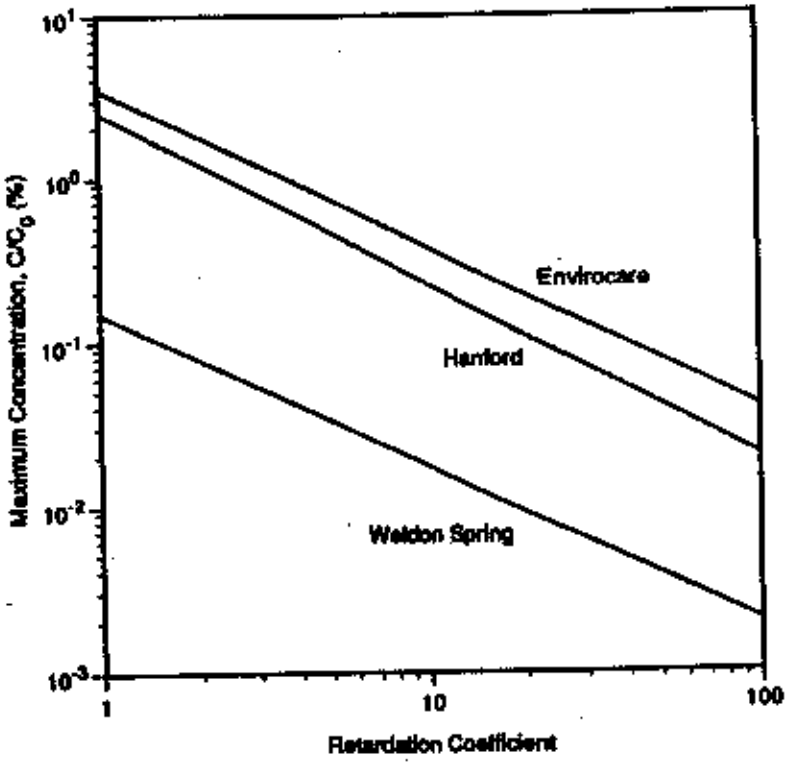

FIGURE D.8 Comparison of Maximum Breakthrough Concentrations at the Receptor Locations for the Alternative Disposal Sites

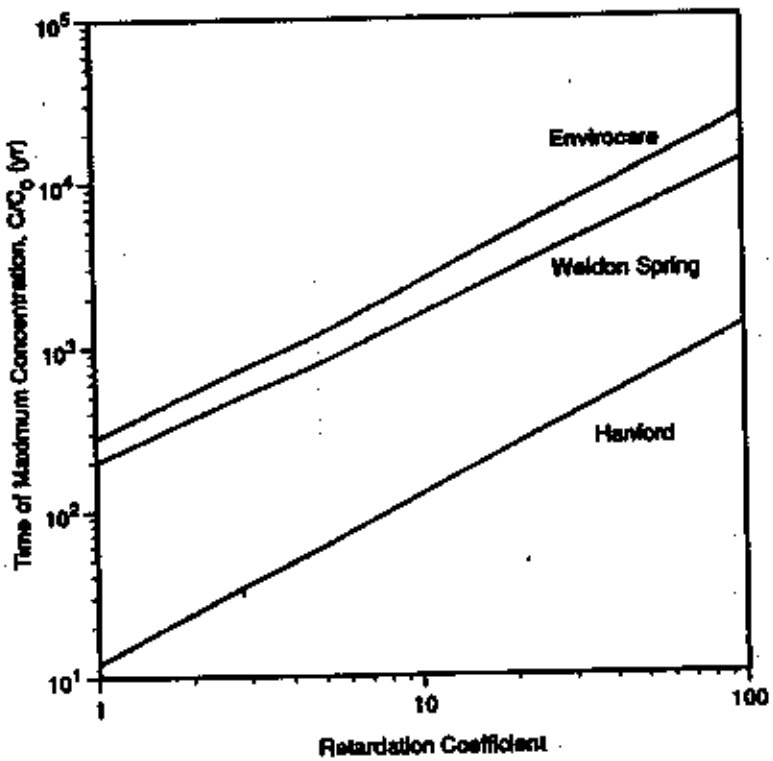

FIGURE D.9 Comparison of the Times of Maximum Breakthrough Concentrations at the Receptor Locations for the Alternative Disposal Sites

D.6 REFERENCES

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APPENDIX E:

REBASELINE HEALTH ASSESSMENT

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REBASELINE HEALTH ASSESSMENT

This "rebaseline" health assessment updates the human health evaluation presented in the baseline assessment (BA) for the chemical plant area of the Weldon Spring site (U.S. Department of Energy [DOE] 1992a). The primary objectives of this assessment are to (1) evaluate health effects for new conditions that will exist at the site after approved interim response actions have been implemented and (2) provide the framework for developing soil cleanup criteria, which are presented in Chapter 2. The approved interim actions include removing and treating surface water and dismantling chemical plant structures. Except for groundwater, soil is the only environmental medium of concern that would remain at the site after these actions are implemented; groundwater is being addressed as a separate operable unit of this cleanup project. (Cleanup criteria have not been developed for raffinate pit sludge and structural debris because they are considered waste that would be removed rather than environmental media that would remain.) The soil cleanup criteria developed on the basis of this assessment were used to identify areas for remediation and support decisions for future land use.

The rebaseline assessment and subsequent development of soil cleanup criteria have been used to assess the performance of remedial action alternatives for the site against two key evaluation factors: (1) compliance with applicable or relevant and appropriate requirements (ARARs) and (2) long-term effectiveness, e.g., relative to the magnitude and nature of residual risk. That is, information presented in this appendix was used to identify potential health impacts for the "rebaselined" no-action alternative against which the action alternatives were compared and to identify estimated residual risks associated with various cleanup options. This information was also used to focus the remaining cleanup decisions for the site.

E.1 SCOPE AND GENERAL APPROACH FOR THE REBASELINE HEALTH ASSESSMENT

The assessment of baseline risks for the Weldon Spring site consists of three phases that parallel major cleanup decision points and associated changes in the site configuration, as described in Section 1.3.1 of the BA (DOE 1992a). The three phases are as follows:

- The first assessment — the BA — evaluated potential health and environmental effects for the site as it existed in early 1992 without accounting for interim actions that had already been approved but not yet completed.

- The second assessment — this rebaseline assessment — evaluates potential health impacts for the site as it will exist after the approved interim actions have been implemented. These actions are currently in various stages of design and implementation, and site conditions will be changing within the next several years. The interim actions for which decisions have already been made include (1) dismantlement of all site structures; (2) construction

and operation of temporary storage and staging areas, i.e., the temporary storage area (TSA) for bulk waste excavated from the quarry and the material staging area (MSA) for structural debris, soil, and construction material from the chemical plant area; and (3) construction and operation of a water treatment plant for surface water in the raffinate pits and other site impoundments. As part of this assessment, impacts are also evaluated for a modified site configuration that focuses on soil-related exposures in order to support the development of soil cleanup criteria.

- The third assessment — to be prepared for the groundwater operable unit — will evaluate the site as it will exist after implementing the cleanup decisions determined from this remedial investigation/feasibility study-environmental impact statement (RI/FS-EIS) and documented in the record of decision. That is, the upcoming assessment is expected to reflect conditions that will result from site remediation — such as soil cleanup and other source control actions, removal of the temporary storage and treatment facilities, and completion of waste disposal.

Each phase includes both a short-term and a long-term component. It was assumed that existing institutional controls — such as DOE ownership, security guards, and monitoring and maintenance activities — would continue in the short term but would be lost in the long term.

For this rebaseline assessment, the short-term component summarizes differences associated with the transitional site conditions resulting from interim actions; this analysis assumes that institutional controls are retained, and it assesses changes in overall health effects from those presented in the BA (DOE 1992a). The long-term component addresses health effects associated with the interim site conditions under an assumed loss of institutional controls. The time period for the short-term assessment was assumed to extend over the next 10 years for on-site exposures and over the next 30 years for off-site exposures. For the long-term assessment, the interim site conditions were assumed to extend into the long-term future, e.g., 100 to 200 years and beyond, with exposure durations of 25 or 30 years depending on the receptor.

The interim actions currently underway represent only a partial completion of site cleanup activities, with additional decisions to be determined from the analyses in this RI/FS-EIS. Therefore, in addition to providing information to support the development of soil cleanup criteria, the long-term assessment must evaluate impacts that might occur if no further cleanup actions were taken at the site beyond those that have already been initiated. This objective is addressed by the first component of the assessment for the site in transition, which is referred to as the long-term assessment of the interim site configuration in this appendix.

The second component of the long-term assessment evaluates exposures related to soil contaminants that might occur in the absence of institutional controls at the site. For this evaluation, a modified site configuration was defined to exclude other areas of contamination — e.g., the raffinate pits, TSA, and MSA — in order to focus on the development of cleanup criteria for soil. The hypothetical loss of institutional controls was assumed to occur in the long-

term future, so additional receptors — including a resident — were evaluated for this assessment compared with the BA. Both the short-term and the long-term analyses of the interim site configuration evaluate the same receptors that were addressed in the BA; the exposure pathways and intake estimates for these receptors are expected to be similar to those discussed in Chapter 3 of the BA, with some modifications to address altered site conditions. The modifications and related changes in estimated health effects are discussed in Section E.2 for the short-term analysis and Section E.3 for the long-term analysis. These two analyses are primarily qualitative. The exposure pathways and the intakes and health effects estimated for the focused long-term assessment of the modified site configuration are discussed in Section E.4; this analysis is primarily quantitative.

Background information on the site is summarized in Section 1.3 of this PS and is presented in considerable detail in the RI (DOE 1992b) and the BA (DOE 1992a) for the chemical plant area. Hence, it is not repeated in this appendix. Soil contamination associated with future conditions is expected to be generally similar to that for current conditions. Therefore, the related contaminants of concern and the toxicity assessment are similar to those presented in Chapters 2 and 4, respectively, of the BA. Because the methodologies used for the exposure assessment, toxicity assessment, and risk characterization are described in considerable detail in the BA, the following discussion makes extensive reference to that document to limit redundancy and focus on new information.

E.2 SHORT-TERM ASSESSMENT OF THE INTERIM SITE CONFIGURATION

This short-term assessment updates conditions evaluated for the short-term assessment in the BA and presents a qualitative comparison of potential impacts associated with new site conditions. The impacts presented in environmental documents for the individual interim actions were used for this comparative analysis. Under the reasonable scenario that assumes institutional controls remain in place over the next 10 years, the following site conditions associated with continued operation and maintenance activities are expected:

- The quarry water treatment plant is operational, and the quarry bulk waste is in controlled storage at the TSA;
- All site structures are dismantled, and the resulting debris is in controlled storage at the MSA (which consists of several staging areas and, for purposes of this assessment, is considered to include the asbestos container staging area); and
- The site water treatment plant is operational.

This analysis of interim site conditions considers the same receptors evaluated in the short-term assessment of the BA — i.e., an on-site maintenance worker, on-site trespasser, and off-site recreational visitor. The exposure assessment and resulting health effects associated with exposures to soil and air are generally similar to those presented in the BA; this information is summarized in Section 1.6 of this FS. Differences in the exposure assessment associated with

changed site conditions (including the new facilities) and the resulting impact on total health effects relative to those estimated in the BA are discussed for these receptors in Sections E.2.1 through E.2.3.

E.2.1 On-Site Maintenance Worker

The exposure pathways assessed in the BA for the on-site maintenance worker were those associated with soil and air. The same pathways are relevant for the rebaseline assessment, and worker impacts would generally be similar to those estimated in the BA. Those areas of the site covered by the MSA, TSA, and water treatment plant would no longer be accessible so related exposures would not be relevant. However, this is not expected to affect estimated health effects because contaminant concentrations in soil at these areas are generally similar to those in other areas of the site.

External gamma irradiation would be the primary exposure pathway during maintenance activities at the MSA and TSA because erosion controls would limit other exposures such as inhalation. Only those workers directly involved in such activities are expected to be exposed because external gamma radiation decreases markedly with distance from the source. Exposures at the MSA are expected to be insignificant because the level of radioactivity associated with structural debris and other material that would be stored there is generally low and the time required to conduct maintenance activities would be limited. In contrast, levels of radioactivity associated with certain quarry material at the TSA would be high.

The screening-level risk for a worker involved in maintenance activities for quarry waste stored at the TSA was estimated to be 8×10^{-5} per year, assuming a conservative dose rate of 0.25 mrem/h over 500 hours per year (DOE 1990b). A more reasonable risk estimate — based on a lower exposure rate and time of 0.1 mrem/h over 100 hours per year, which is more likely — would be 6×10^{-6} per year. This value is about double the incremental risk estimated for a maintenance worker from exposure to external gamma radiation from sitewide soil under previous baseline conditions (3×10^{-5} over the 10-year period, or 3×10^{-6} per year).

Workers involved in water treatment plant operations would be exposed to external gamma irradiation from the containerized process waste. The occupational risk from this exposure was calculated on the basis of a conservative exposure rate of 0.1 mR/h (MacDonell et al. 1990), a conversion factor of 0.95 mrem/mR, and the conservative assumption that a worker would spend about 40 hours per year doing maintenance activities for the limited number of containers; the risk calculated for this exposure is about 2×10^{-6} per year. If it is assumed that process waste from the treatment plant would be stored with the quarry waste at the TSA, the combined risk to a worker at the TSA would be about 8×10^{-6} per year. This value is about three times higher than the incremental risk estimated for the routine maintenance worker from sitewide external gamma irradiation under baseline conditions. Combined with the risk from exposures to sitewide soil and air over the 40 hours per year, the total risk for the additional worker would be about 1×10^{-4} over a 10-year period.

In summary, the potential risk to the additional worker under the interim site conditions is expected to be about 20% of the risk estimated for the routine maintenance worker under baseline conditions (Section 5.2 of the BA). The worker responsible for sitewide maintenance activities, such as mowing grass and maintaining the perimeter fence, is not expected to also conduct the maintenance activities at the new facilities because the routine maintenance activities are assumed to require 8 hours per day. Therefore, if it is assumed that the new work force for site maintenance would consist of two individuals, adding a second worker to maintain the interim storage areas would slightly increase the total risk for the combined work force. However, the potential risks for these workers are expected to be generally similar under both baseline and new site conditions.

E.2.2 On-Site Trespasser

The two exposure points that contributed substantially to the total health effects evaluated for the trespasser in the BA — i.e., the buildings and the raffinate pits — are not relevant to the short-term rebaseline assessment. For baseline conditions, radiological and chemical risks estimated for trespasser exposures at the buildings and raffinate pits represent more than 98% of the totals for all potential sources; the hazard index estimated for the buildings alone exceeds 1, so they represent the primary source of potential noncarcinogenic impacts. Indoor building exposures would no longer be possible under new site conditions because the buildings would have been dismantled and the debris placed in short-term storage at the MSA. For the raffinate pits, the likelihood of exposures would be low because the water treatment plant would be operational and the presence of workers would limit trespassing.

Similarly, the likelihood of trespasser exposures at the newly constructed MSA and TSA would be low because of the increased level of worker activity. In addition, exposures estimated in the BA for soil at the locations of the new facilities would no longer be relevant; however, as for the worker, this difference is not expected to change estimated health effects. Because impacts associated with exposures at the buildings and raffinate pits would no longer occur under new site conditions, potential impacts to the trespasser would only be associated with exposures to soil and air; these impacts would be similar to those presented in the BA. Therefore, the radiological and chemical risks for the trespasser would decrease to 2% or less of those indicated in the BA for combined exposures, i.e., 2×10^{-6} and 2×10^{-7}, respectively. In addition, the estimated hazard index would be much less than 1, so no noncarcinogenic effects would be expected under the interim site conditions.

E.2.3 Off-Site Recreational Visitor

Off-site conditions are not expected to change within the next 30 years, with the possible exception of flows in the Southeast Drainage. Hence, impacts for the recreational visitor are expected to be generally similar to those presented in Section 5.3 of the BA. For the Southeast Drainage, the baseline exposure point concentrations evaluated for surface water in the BA's preliminary assessment could change if effluent were discharged to the drainage from the water

treatment plant that is being constructed on-site under an interim action (MacDonell et al. 1990). Under this action, water from on-site impoundments is to be treated in the newly constructed treatment plant, and effluent is to be released to the Missouri River. The effluent might be released to the drainage for gravity flow to the river during the initial operating period of the treatment plant, depending on the completion schedule for the recent pipeline modification (Section 1.5.1.4). To be conservative, the analysis of potential incremental impacts associated with this interim action assumes that the treated water would be discharged to the Southeast Drainage during the entire 10-year operational period projected for the plant. Results would be expected to bound potential impacts associated with a shorter-term release.

Exposure assumptions identified for the off-site recreational visitor in the BA were used to estimate the risk associated with ingesting treatment plant effluent from the Southeast Drainage. That is, the hypothetical receptor was assumed to visit the drainage 20 times per year and ingest 0.2 L of surface water during each visit over the discharge period. Residual levels in the treated water were developed for the key contaminants in conjunction with the state of Missouri as part of the decision-making process for the interim action. For this analysis, contaminants were assumed to be present in the effluent at their established limits, and it was assumed that the effluent was ingested directly, i.e., without mixing with other flows in the drainage.

To be conservative, it was assumed that uranium and radium would always be present in the effluent at their full discharge limits of 100 pCi/L for total uranium and 5 pCi/L for radium-226 and radium-228 combined (MacDonell et al. 1990). The radiological risk estimated for directly ingesting effluent from the drainage over the entire discharge period is 8×10^{-7}. Most of this risk is attributable to uranium; radium contributes less than 20%. The risk from ingesting treatment plant effluent from the Southeast Drainage is about 20% of that estimated for ingesting surface water from the drainage under baseline conditions over the same period (4×10^{-6}). A time-adjustment factor was applied to account for the fraction of the total exposure period assumed for the BA (30 years) during which effluent would be discharged (10 years).

As a screening-level estimate, results for the effluent analysis were combined with those for the time-adjusted baseline analysis to assess potential cumulative impacts during the discharge period. The combined radiological risk from ingesting surface water in the drainage during the 10-year period is 5×10^{-6}; this value is about 20% higher than the baseline estimate for this exposure route. However, the increased risk from surface water ingestion would not appreciably change the total radiological risk estimated for combined exposures at the drainage from ingestion of surface water and incidental ingestion of sediment under baseline conditions (2×10^{-4}) for two reasons. First, exposures to sediment account for most of the risk (about 95%), and second, incremental exposures to treatment plant effluent would occur during only a portion of the total exposure period assumed for this individual. In summary, overall radiological risks to the off-site recreational visitor under new site conditions are expected to be comparable to those presented in the BA.

The chemical risk associated with ingesting treatment plant effluent from the Southeast Drainage was estimated with the same conservative assumptions described above, including the

assumption that the expected contaminants of concern in the effluent are always at the limits identified in MacDonell et al. (1990). (Potential exposure to cyanide was not assessed because, although an effluent limit was identified for this contaminant, it is not expected to be present. Cyanide was detected in early sampling of the raffinate pits and was therefore included in the preliminary design of the water treatment plant to be conservative, but it has not been detected in subsequent sampling at the pits and appears to have been oxidized to nonhazardous end products over time.) The chemical risk estimated for ingesting effluent from the drainage over the 10-year operational period of the plant is about 4×10^{-6}, which is about 10 times higher than that identified for ingesting surface water from the drainage under baseline conditions over the same period. Most of the risk is attributable to 2,4-dinitrotoluene (2,4-DNT) and arsenic. The hazard index estimated for this period is less than 1 for both the baseline and interim site conditions.

If the results for the effluent analysis are combined with those for the time-adjusted baseline analysis, the chemical risks from surface water ingestion during the operational period of the treatment plant are estimated to be about 4×10^{-6}. The total combined chemical risk over the entire exposure period would be 4 times higher than that indicated for the preliminary assessment of baseline conditions, or about 5×10^{-6}. Therefore, chemical risks for an off-site recreational visitor at the Southeast Drainage could increase slightly on the basis of conservative exposure assumptions, but it is expected that not all of that receptor's exposures would occur at this location throughout the 10 years. For this reason, potential impacts to this receptor over the entire exposure period, considering the new site conditions, are expected to be generally similar to those presented for the combined exposure points in the BA. Additional characterization data that will be collected for the Southeast Drainage within the next several years will be used to refine this preliminary assessment.

E.3 LONG-TERM ASSESSMENT OF THE INTERIM SITE CONFIGURATION

The long-term assessment of the interim site conditions evaluates health effects that might occur if institutional controls were lost in the future and no further cleanup action had been taken at the site. This limited analysis provides the transition between baseline conditions evaluated in the BA (which did not include changes associated with recently approved interim actions that have not yet been fully implemented) and the modified site configuration evaluated to focus the development of soil cleanup criteria. For this analysis, potential exposures were estimated for a future on-site recreational visitor assuming that operation and maintenance activities cease at the new facilities when institutional controls are lost. Such an assumption is purely hypothetical because a commitment has been made for full site cleanup and activities are well under way to achieve this purpose. Also, in the unlikely event that full cleanup were postponed, additional actions would first be implemented to further stabilize the temporary facilities. Nevertheless, the following site conditions were assumed to occur over time if site controls were lost: the raffinate pits and ponds refill with water after treatment plant operations cease and erosion controls at the TSA and MSA eventually fail such that erodible material is subject to dispersal.

The exposure assessment and the estimated health impacts for this analysis are generally similar to those presented in the BA and summarized in Section 1.6 of this FS. However, some adjustments were made to reflect new site features; that is, exposures inside buildings were excluded because the buildings would have been dismantled and exposures associated with the new facilities were added because maintenance activities would have ceased.

For the case in which the exposures of a recreational visitor over 30 years were assumed to be distributed between the buildings, raffinate pits, and sitewide soil, exposures in the buildings accounted for about 35% of the total radiological risk and estimates for the raffinate pits essentially contributed the balance; building exposures accounted for about 97% of the chemical risks. If the recreational visitor were to divide exposures between walking across the site and visiting the buildings, both the radiological and chemical risks from building exposures would account for more than 95% of the total risks. Hence, after the buildings have been dismantled, overall risks could be reduced by these amounts for the case where exposures are evenly distributed. In addition, the potential for noncarcinogenic health effects would no longer be indicated because the buildings alone accounted for the hazard index above 1 for this receptor.

Overall health effects associated with exposure to site soil could increase above those presented in the BA as a result of accessibility to and/or dispersal of erodible material from the TSA. However, dispersal is not expected to be widespread because site-specific conditions would tend to limit erosion. For this reason, it is expected that much of the quarry material stored at the 5.4-ha (13-acre) TSA location would remain there rather than being distributed across the site. Hence, exposures to this material could be estimated by considering the results of the baseline risk evaluation that addressed exposures to the material in place at the 3.6-ha (9-acre) quarry (DOE 1990a). Although specific contaminant levels are not yet known for all of this material (the quarry bulk waste will be further characterized upon placement in the TSA), an approximation can be made from the information in the previous assessment. This approach is expected to conservatively represent potential future health impacts associated with this waste because the exposure point concentrations would be lower if the material were dispersed.

The radiological and chemical risks estimated for a trespasser in the previous quarry assessment were 9×10^{-5} and 4×10^{-5}, respectively, assuming a plausible maximum exposure of 4 hours per visit and 50 visits per year for 10 years. In addition, the hazard index exceeded 1, so noncarcinogenic impacts were indicated. Because the total number of visits to the TSA location by a recreational visitor is expected to be lower, related risks under rebaseline conditions would also be lower. For example, if it is assumed that the recreational visitor would spend 25% of each visit at the TSA over the entire 30-year exposure period, the radiological and chemical risks would be about 2×10^{-5} and 1×10^{-5}, respectively, but noncarcinogenic effects could still be indicated.

Overall health effects associated with the MSA are not expected to increase above those estimated in the BA because (1) the stored material would be similar to the material found on-site under baseline conditions preceding its removal and (2) little of the contaminated structural debris and equipment would probably be dispersed. If waste drums and bin

containers failed over time, containerized building debris such as PCB-contaminated material might be released. However, potential exposures to such material are expected to be somewhat less than those described in the BA for a recreational visitor because concentrations from the most highly contaminated buildings were used for that assessment, so impacts from exposure to all building-related material are probably overestimated. In addition, exposure to indoor radon decay products would not be relevant to the new site conditions, and this exposure accounted for about 30% of the radiological risks associated with the buildings under baseline conditions. Because exposures are generally expected to be less than those conservatively estimated for baseline conditions, overall impacts to the recreational visitor associated with the storage and staging areas are expected to be lower than those presented in the BA for related material.

Following the cessation of treatment plant operations, exposures at the raffinate pits (and other impoundments) and related health effects could be similar to those described in the BA because the impoundments might refill with water and again serve as a source of potential exposure. In summary, the changes associated with interim site conditions are expected to balance each other so that overall impacts to the recreational visitor would be generally similar to those presented in the BA.

E.4 LONG-TERM ASSESSMENT OF THE MODIFIED SITE CONFIGURATION

The long-term assessment of the modified site configuration addresses soil-related exposures that might occur in the extended absence of institutional controls. The results of this assessment provide the framework for developing cleanup criteria for site soil, which are discussed in Chapter 2 of this FS. To focus this assessment on soil contaminants, the raffinate pits and temporary facilities (MSA, TSA, and water treatment plant) were "set aside," having already been addressed in the assessments of interim conditions. For this analysis, health effects from soil-related exposures were estimated for four hypothetical future on-site receptors: a recreational visitor, a wildlife area ranger in an on-site ranger station, a resident, and a resident farmer (hereafter referred to as the farmer). The assessment addresses pathways associated with both direct and indirect exposures to soil, e.g., external gamma irradiation, incidental soil ingestion and inhalation of airborne particulates.

E.4.1 Exposure Assessment

E.4.1.1 Exposure Pathways

The soil-related exposure pathways for the on-site recreational visitor are the same as those presented in Table 3.1 and Section 3.2 of the BA. For the on-site ranger, resident, and farmer, the following pathways were evaluated: external gamma irradiation, inhalation of outdoor and indoor radon and contaminated airborne particulates, incidental ingestion of outdoor soil and indoor dust, and ingestion of fish and game. Two additional ingestion pathways were assessed for the farmer: homegrown fruits and vegetables, and beef and dairy

products. The pathways evaluated for the various receptors are identified in Table E.1.* This table also shows the basis for the exposure point concentrations used in this analysis, which are discussed in Section E.4.1.3.

A preliminary assessment was also conducted for the groundwater pathway. The very limited data available for the deep aquifer in the St. Peter Sandstone (which is the productive aquifer in the area) do not indicate that the aquifer is contaminated. In contrast, the data available for the upper aquifer in the Burlington-Keokuk Limestone at the site have identified elevated concentrations of uranium, nitroaromatic compounds, inorganic anions, and some heavy metals. These data for the shallow aquifer were used for the groundwater analysis, even though sustainable pumping rates measured for this aquifer (1 L/min [0.3 gal/min]) have been lower than the typical rate needed to support a household, so it would not be expected to be used for such purposes at the site. (This expectation is borne out by the depths of residential wells in the area, which extend to the deeper, productive aquifer.)

The intent of the preliminary groundwater assessment was to provide an early indication of potential health effects for this medium and to permit the summation of health effects across reasonable multiple pathways. To provide this information, potential health effects were assessed for the resident from drinking water ingestion on a location-specific basis. A separate analysis was not conducted for a resident farmer, e.g., to address irrigating a garden or providing water to a cow because current data indicate that a well completed in the upper aquifer of the site would not sustain all of these uses. Therefore, estimates for the farmer would be bounded by those determined for the resident. After additional data are collected, this preliminary assessment will be revised to address other considerations, such as those described for a farmer scenario, in documentation to be prepared for the groundwater operable unit to be prepared within the next several years.

The analyses described thus far address potential health effects associated with surface soil contamination. To evaluate the contribution from subsurface contamination, potential impacts were assessed for two scenarios: leaching of soil contaminants to groundwater and redistribution onto the site surface of soil excavated for the basement of a residence. Contaminant leaching was evaluated so that potential future impacts to groundwater could be factored into the development of soil cleanup criteria. This evaluation was conducted in accordance with guidance from the U.S. Environmental Protection Agency (EPA 1989b). The approach used to predict future groundwater concentrations is discussed in Section E.4.1.3, and the results of this analysis are presented in Section E.4.2.

For the soil redistribution scenario, the contaminants were assumed to be mixed during excavation, stockpiling, and redistribution on the surface such that the new surface would contain the average concentrations in the 3 m (10 ft) of soil assumed to be excavated for a basement. Exposures of the resident to this new surface soil were evaluated with weighted

*For readability, all tables are presented in sequence at the end of the text and figures in this appendix. Because values were rounded to one and two significant figures (for the estimated health effects and intakes, respectively), summations within tables will not be exact.

averages of the contaminant concentration data over this depth. Because the methodology for this assessment parallels that used for addressing exposures to current surface soil concentrations, it is not explicitly discussed in Sections E.4.1.2 and E.4.1.3. However, the results of the redistribution analysis — i.e., estimated risks and hazard indexes — are discussed in Section E.4.2. This information was used to identify areas of subsurface contamination that might contribute to health impacts under possible future conditions, so they could be factored into the comprehensive cleanup decisions for the site.

E.4.1.2 Scenario-Specific Assumptions and Intake Parameters

The scenario assumptions and intake parameters used to estimate radiological and chemical exposures for the recreational visitor, ranger, resident, and farmer are summarized in Table E.2. Because the values for the recreational visitor are the same as those used for this receptor in the BA (as described in Table 3.3 and Section 3.4.2 of that document), the supporting rationale is not repeated here. The rationale for selecting values for the three new receptors is included in the following discussion.

Exposure Time, Frequency, and Duration. The three parameters — exposure time, frequency, and duration — together define the total extent of exposure at an exposure point. The exposure time is the number of hours per day (or hours per exposure event) that a receptor is present at a specific exposure point; the exposure frequency is the number of days per year (or events per year) that exposure occurs; and the exposure duration is the total number of years over which exposure occurs. For this assessment, the time allotted to indoor and outdoor activities is important for certain exposure pathways, such as inhalation of radon and external gamma irradiation, because indoor and outdoor exposures differ. Hence, as appropriate to the exposure pathway, the exposure time has been divided into time spent indoors and time spent outdoors.

The ranger was assumed to be on-site 8 hours per day, 250 days per year, over 25 years. The exposure time assumes a normal 8-hour working day, and the exposure frequency and duration are the standard values recommended for a worker by the EPA (1991a). The ranger was assumed to spend 4 hours per day indoors doing office work and 4 hours per day outdoors conducting trail maintenance and other activities.

The resident and farmer were assumed to be present at their residences 24 hours per day, 350 days per year, over 30 years. These values are recommended by the EPA for reasonable maximum residential exposures (EPA 1991a). The resident and farmer were assumed to spend 23 and 20 hours per day indoors and 1 and 4 hours per day outdoors, respectively, averaged over the entire year.

Inhalation Rates. Scenario-specific inhalation rates were derived for the ranger, resident, and farmer; separate inhalation rates were developed for indoor and outdoor exposures because air concentrations of particulates and radon will differ (Section E.4.1.3). The default

value of 20 m^3/workday (2.5 m^3/h) provided by the EPA (1991a) is considered to be the "reasonable maximum exposure" for a worker engaged in heavy outdoor activities such as construction or road maintenance (Dinan 1991), and this value was used to assess the ranger's outdoor exposures. For indoor exposures, the ranger was assumed to conduct office work and other light activities for which the average inhalation rate was estimated to be 1 m^3/h (EPA 1989a). The ranger was assumed to spend the entire workday within the area impacted by site contamination. This assumption is expected to overestimate potential exposures and risks because the site represents only a small fraction (less than 2%) of the surrounding wildlife area and it is likely that much of the ranger's outdoor time would be spent in uncontaminated areas off-site.

The EPA's standard default value of 20 m^3/d was used for the resident's inhalation rate; this value represents a combined value for indoor and outdoor residential activities. On the basis of reasonable activity patterns and related inhalation rates for a resident, the inhalation rate derived for indoor exposures was 0.8 m^3/h and that for outdoor exposures was 1.6 m^3/h. For the farmer, the level of indoor activity is expected to be generally similar to that assumed for the resident, so the inhalation rate of 0.8 m^3/h was used. However, the level of outdoor activity for a farmer would be higher than that for a typical resident; therefore, the EPA-recommended value of 2.5 m^3/h for a worker involved in heavy activities was used to assess the farmer's outdoor inhalation exposures.

Ingestion Rates for Soil and Dust. Individuals might ingest soil and indoor dust either inadvertently (e.g., by transfer from hands and fingers to food or cigarettes) or intentionally (by pica). Pica behavior is generally associated with young children (1 to 6 years old) and refers to an abnormal ingestion of soil (from 1 to 10 g per day) additional to soil that all children inadvertently ingest as part of normal mouthing behavior (about 0.2 g per day). Although studies are limited, EPA guidance indicates that the incidence of pica behavior in the normal population is extremely low, so this behavior is not explicitly addressed in a risk assessment (EPA 1989a).

Interim guidance from the EPA (1991a) for soil ingestion rates recommends the following values: (1) 50 mg/d for a worker at a commercial or industrial property and (2) a combined value for a resident, assuming an ingestion rate of 200 mg/d for children (aged 1 through 6, with an average body weight of 15 kg) and 100 mg/d for all other ages (i.e., for the remaining years, with an average body weight of 70 kg).

Considering the nature of a ranger's activities compared with those of a worker at a commercial or industrial setting, the rate of soil ingestion was increased to 120 mg per workday for this assessment. This value was derived in the same manner as that described in the BA for the recreational visitor (Section 3.4.2.3 of the BA). A value of 180 mg/d was used for the farmer because higher exposures would be expected from farming activities. This value was estimated with the same general assumptions used for the ranger and recreational visitor. For this assessment, the ingestion rates for the ranger, resident, and farmer include both outdoor soil and indoor dust.

Ingestion Rates for Drinking Water. The drinking water ingestion rate used for the resident was 2 L/d, which is the standard default value recommended by the EPA (1991a). The drinking water source was assumed to be an on-site well. Because wells are not expected to be present under a future recreational scenario, this pathway was not quantified for the recreational visitor or the ranger; the analysis for the resident includes the area that was defined for the farmer, so potential impacts for the farmer are bounded by the location-specific resident analysis. (The groundwater analysis in this document is preliminary because of current data limitations, so it has been simplified to address the representative receptor, i.e., the resident. Potential impacts for other receptors will be addressed in forthcoming environmental documentation for the groundwater operable unit.)

Ingestion Rates for Food. The ingestion rates for homegrown food for the farmer are the standard default values provided by the EPA (1991a). The rates recommended for ingestion of homegrown fruits, vegetables, beef, and dairy products are 42, 80, 75, and 300 g/d, respectively. The rates for ingestion of fish and game were determined from site-specific data, including catch limits and area-use information for the Busch Wildlife Area lakes, maximum allowable takes of game animals in the Weldon Spring area, estimates of the weights of edible portions, and consumption rates; this information is presented in Section 3.4.2.5 and Table 3.4 of the BA.

Body Weight. The value for body weight was taken to be the average value appropriate for each receptor over the indicated exposure period. In accordance with EPA (1991a) guidance, a value of 70 kg was used for the average adult body weight for the ranger, resident, and farmer. To address differences in soil ingestion rates, a body weight of 15 kg was used to estimate soil ingestion for the resident over a 6-year exposure period (to account for the childhood years with a soil ingestion rate of 200 mg/d) and a body weight of 70 kg was used over the remaining 24 years of the assumed 30-year exposure period (to account for the remaining years with a soil ingestion rate of 100 mg/d).

Averaging Time. Two intake estimates were calculated for each exposure point and route of exposure, one for each of two different averaging times. The first was the estimated average daily intake over an exposure duration of 25 years (9,125 days) for the ranger and 30 years (10,950 days) for the resident and farmer. The average daily intake for these two exposure durations was used to estimate potential noncarcinogenic health effects associated with the chemical contaminants of concern. The second intake estimate was the total intake estimated for the 25- or 30-year period, averaged over a lifetime of 70 years (25,550 days). The lifetime average was used to calculate carcinogenic risks for the chemical contaminants because the EPA slope factors for estimating these risks are based on an exposure period of 70 years. Although these averaging times are different, the total intakes for the scenario-specific exposure durations are the same as those for the lifetime period.

E.4.1.3 Exposure Point Concentrations and Estimates of Contaminant Intakes

As appropriate to the scenario and route of exposure, the exposure point concentrations of contaminants in air and surface soil were determined by one of three approaches. The sitewide approach used the 95% upper confidence limit of the arithmetic average (UL_{95}) for all surface measurements. The location-specific approach used the concentrations associated with each borehole, assuming that a resident could live at any one of the sampling locations. The farmer-area approach consisted of two methods: for chemical contaminants, the UL_{95} values of the arithmetic average from borehole measurements in the Ash Pond area (Figure E.1*) were used. This approach was also used for the radionuclides, except for uranium, incorporating information from the radiological source term analysis for those radionuclides not directly measured (see Table 2.3 of the BA). For uranium, a contour-weighted value was determined by kriging the measurements from the Ash Pond area. (Contour-weighted averages were also determined for radium and thorium from measurements in the Ash Pond area; these more representative values were much lower than those estimated by applying information from the source term analysis to the uranium value. However, to be conservative, the exposure point concentrations used for radium and thorium in this assessment were determined from the values for uranium.)

The sitewide approach was applied for cases in which a receptor's activities would be expected to occur at random locations across the site, as for the recreational visitor and the ranger during outdoor activities. The location-specific approach was applied to address exposures that would be expected to occur at fixed locations, such as the ranger station and the resident's or farmer's house. That is, it was assumed that the ranger station and the residence could be constructed at any one of the numerous borehole locations, so all relevant exposure pathways were assessed for the ranger and the resident at each individual location. From the spatial distribution of the boreholes, these locations typically represent 0.1 to 0.2 ha (0.25 to 0.5 acre).

Because more space is required for a family farm than for a typical residence, an area approach, rather than a location-specific approach, was used for the farmer analysis. An area of 1 ha (2.5 acres) has been identified as reasonable for supporting a single cow, and 2 ha (5 acres) has been identified as reasonable for the farm of a four-person family (Gilbert et al. 1989). The 4-ha (10-acre) Ash Pond area was evaluated for the family farm scenario because this location is the most radioactively contaminated and also contains most of the chemical contaminants of concern. The bases for the exposure point concentrations used for each receptor and pathway are shown in Table E.1.

For the analyses of future land-use scenarios, contaminant levels in soil were assumed to be similar to those under current conditions. Because processing operations have long since ceased at the site, this is expected to be a reasonable but conservative assumption for estimating exposure point concentrations, with one exception. The concentrations of some radionuclides could increase as a result of ingrowth over a future time period that extends to thousands of

*For readability, all figures are presented in sequence at the end of the text of this appendix.

years. For example, ingrowth of radium-226 from uranium would produce a peak concentration of radon-222 after about 200,000 years. This factor was considered in developing cleanup criteria for site soil. In general, the levels of other soil contaminants would be expected to decrease over time as a result of natural processes such as erosion, atmospheric deposition from uncontaminated sources, and biodegradation (for organic compounds).

A large number of data points are associated with this assessment because analyses were conducted for more than 30 different chemicals at about 300 separate locations, with a similar number of locations sampled for radionuclides. Therefore, the exposure point concentrations and intakes estimated for each location are not presented in this document. However, to provide information that could be used to repeat an example calculation of risks and hazard quotients for a resident from exposures to soil and air, three locations were selected for presentation. These represent the locations at which the median radiological risk, chemical risk, and hazard index were determined for the resident. Because the values for the median risks and hazard index also apply to a large number of other locations (reflecting the general similarity of contamination across much of the site), they are not shown on a figure. The exposure point concentrations, radiological doses, and associated risks for the median radiological risk location are presented in Table E.3. The exposure point concentrations, chemical intakes, and risks and hazard quotients for the respective median locations for chemical contaminants are given in Tables E.4 and E.5. The exposure point concentrations, doses, and intakes estimated for the farmer from ingestion of homegrown food are presented in Tables E.6 and E.7. The results of the analyses for all receptors considering all relevant locations — i.e., the estimated carcinogenic risks and hazard indexes — are presented in Section E.4.2. The specific methodology and assumptions used to derive the exposure point concentrations and estimate contaminant intakes for this assessment are summarized in the following discussion.

External Gamma Irradiation. The dose from external gamma irradiation was calculated by multiplying the length of time an individual is assumed to be exposed to the given radiation field by the measured field strength and the dose conversion factor of 0.95 mrem/mR (as discussed in Sections 3.3.1.1 and 3.4.3.1 of the BA). A background exposure rate of 10 μR/h was subtracted from each exposure point concentration to identify the incremental effect of site contamination. (At most locations, natural background radiation is the major contributor to the total external gamma dose.) For the redistribution scenario, the dose was calculated with information from the radiological source term analysis and Equation 3.9 from the BA. To estimate the dose during time spent indoors for the ranger, resident, and farmer, a shielding factor of 0.7 was used to account for attenuation by the walls and floor (Gilbert et al. 1989).

Inhalation of Outdoor and Indoor Air. Airborne particulates and radon in both outdoor and indoor air have been addressed in this assessment. Following the approach developed in the BA, outdoor air particulate concentrations were assumed to be typical of those measured in rural areas in Missouri, with 50% of the respirable fraction originating from contaminated soil. On the basis of these assumptions, the concentration of respirable particulates from contaminated soil was estimated to be 0.025 mg/m^3 (Section 3.3.4 of the BA). This estimate

was combined with the contaminant concentrations in surface soil at the site to calculate airborne contaminant concentrations for the various receptors. For indoor air, it was assumed that 80% of airborne particulates other than those resulting from the radioactive decay of radon gas (which were estimated separately) are derived from outdoor airborne particulates (Stern 1976; Ozkaynak 1991).

The sitewide UL_{95} for each contaminant in surface soil was used to calculate airborne contaminant concentrations under future conditions for the recreational visitor and for outdoor exposures of the ranger. A location-specific analysis was conducted for all other inhalation calculations; the analysis was based on the assumption that airborne contaminants originated from the soil at each discrete sampling location as a result of dust-generating activities. The methodology for deriving the soil concentrations used to estimate the airborne contaminant concentrations for the sitewide and location-specific analyses is given in the following subsection on incidental ingestion of soil and dust. The intakes of radioactive and chemical contaminants for indoor and outdoor air were estimated with Equations 3.15 and 3.16, respectively, from the BA.

The exposure point concentrations for radon-222 and its short-lived decay products in outdoor air were determined by estimating the emanation from radium-226 (sitewide UL_{95}) in surface soil, as described in Section 3.3.4 of the BA. The exposure point concentrations for radon-222 and its short-lived decay products in indoor air were determined by estimating the amount of radon gas that would enter the structure (i.e., the home or the ranger station) at each location and the concentration of decay products that could accumulate inside. The gas was assumed to enter the structure from the surrounding soil, primarily through the basement or foundation slab. The indoor concentrations of radon-222 decay products in units of working level (WL) were estimated for the ranger, resident, and farmer with a conversion factor of 0.0041 WL per pCi/g of radium-226 in surrounding soil (Gilbert et al. 1983). The doses from exposure to indoor and outdoor radon were estimated with Equation 3.14 from the BA. The local background concentration of 1.2 pCi/g for radium-226 was subtracted from the soil exposure point concentration to identify incremental effects for both indoor and outdoor radon.

Sources other than subsurface soil could also contribute to indoor radon, such as volatilization from well water used by a resident. Water sources are estimated to contribute approximately 1 to 7% of the radon concentration in indoor air in the United States (Milvy and Cothern 1990). For cases in which the radon concentration of a domestic water supply is elevated (e.g., from 500 to 10,000 pCi/L), volatilization from water in a home is still estimated to contribute only about 5 to 12% of the total indoor radon concentration (Cross et al. 1985). Elevated concentrations of radium-226 have not been detected in groundwater of the Burlington-Keokuk Limestone aquifer, and minimal radium-226 contamination exists at depth (i.e., most radium-226 contamination is present in the top 0.3 m [1 ft] of soil at the site, and elevated levels have not been measured beyond a depth of 2.4 m [8 ft]). Therefore, radon is not expected to be elevated above background in well water at the site. As a point of reference, background radon concentrations in groundwater in St. Charles County, Missouri, have been reported to be less than 100 pCi/L (Longtin 1990).

From this information, the contribution to total indoor radon associated with volatilization from well water would be insignificant on the basis of current contaminant conditions, i.e., less than a few percent relative to other sources. For these reasons, the potential contribution to indoor radon from groundwater was not separately assessed for the resident. However, a preliminary assessment of this pathway was performed to address potential future conditions under which radium-226 is assumed to have leached to groundwater.

Incidental Ingestion of Soil and Dust. For the ingestion of outdoor soil and indoor dust, the exposure point concentrations were the same as those derived in the BA for the sitewide and location-specific analyses (Section 3.3.1 of the BA). The exposure point concentrations used for the family farm scenario were as described in the introductory discussion of this section. These concentrations, which were also used for the farm-related food ingestion pathways, are given in Tables E.6 and E.7. For the ranger, resident, and farmer, the contaminant concentrations in indoor dust were conservatively assumed to be the same as those in outdoor soil.

The intakes of radioactive and chemical contaminants from incidental ingestion of outdoor soil and indoor dust were estimated with Equations 3.10 and 3.11 from the BA for all receptors except the resident. For the resident, Equation 3.11 was modified to take into account the different body weights (15 and 70 kg), and both equations were modified to address the different soil ingestion rates (200 and 100 mg/d) assumed over the 30-year period, as described in Section E.4.1.2.

Ingestion of Fish and Game. The methodology and assumptions for ingestion of fish and game are described in Sections 3.3.5 and 3.4.7 of the BA. The intakes of radioactive and chemical contaminants from ingestion of fish and game were estimated with Equations 3.17 and 3.18 from the BA.

Ingestion of Fruits and Vegetables. The methodology and assumptions used to estimate exposure point concentrations in fruits and vegetables for the family farm scenario are the same as those described for estimating contaminant concentrations in plants for the game ingestion pathway in Sections 3.3.5 and 3.4.7 and Appendix E of the BA. The initial exposure point concentrations (in soil) were determined as previously described for ingestion of soil and dust at the Ash Pond area. Secondary exposure point concentrations (in fruits and vegetables) were estimated with the methodology described for vegetation in Section 3.3.5.2 and Appendix E of the BA. The intakes of radioactive and chemical contaminants from ingesting fruits and vegetables were estimated with Equations 3.17 and 3.18 from the BA, assuming that all of the homegrown food ingested would be from the contaminated Ash Pond area.

Ingestion of Beef and Dairy Products. The methodology and assumptions used to estimate ingestion of beef and dairy products for the family farm scenario were similar to those identified for ingestion of game animals in Section 3.3.5.2 of the BA. The initial exposure point

concentrations (in soil) were determined as described for ingestion of soil and dust at the Ash Pond area. Secondary exposure point concentrations (in grass and cow meat) were estimated with the methodology described for vegetation and game animals in Section 3.3.5.2 and Appendix E of the BA. For dairy products, exposure point concentrations were estimated with milk biotransfer or assimilation factors from the scientific literature (Table E.8). The milk biotransfer factor represents the fraction of the contaminant ingested daily with dietary plant tissue that is transferred to and remains in milk. It is represented by the ratio of the concentration in milk (pCi/L for radionuclides and mg/L or mg/kg for chemicals) per daily intake of contaminant (pCi/d for radionuclides and mg/d for chemicals). The intakes of radioactive and chemical contaminants from ingestion of homegrown beef and dairy products were estimated with Equations 3.17 and 3.18 from the BA, assuming that all homegrown food would be from the contaminated Ash Pond area.

Ingestion and Inhalation of Groundwater Contaminants. The preliminary analysis of exposure to groundwater contaminants for this stage of the site evaluation process addresses both current and possible future conditions. For the current assessment, location-specific concentrations were estimated for key contaminants from the limited data available, by contouring averages of measured concentrations from monitoring wells completed in the shallow (Burlington-Keokuk Limestone) aquifer. (Contaminants with a very low detection frequency could not be appropriately contoured; the available averages are discussed in Appendix B of the BA.) The concentration contours were then correlated with appropriate soil boreholes to estimate concentrations for the location-specific analyses.

To evaluate exposures associated with potential groundwater contamination in the long-term future, exposure point concentrations were predicted by modeling the leaching of contaminants from soil to groundwater. This modeling approach was applied because current contaminants would be transported away from the site by groundwater flow over time, so the contaminant concentrations in groundwater in the extended long term would reflect the contribution from soil leaching. (Although leaching would reduce contaminant concentrations in soil, for conservatism this reduction was not considered in assessing the soil-related pathways for the future land-use scenarios.) The sitewide surface UL_{95} values were evaluated for inorganic contaminants to provide a general indication for the site as a whole relative to potential future groundwater contamination. Leaching predictions were not determined on the basis of sitewide UL_{95} values for organic compounds because these contaminants have been detected at only a few locations. Instead, a separate location-specific analysis was conducted to provide a preliminary indication of potential impacts for organic compounds at the individual contaminated locations, to address the scenario under which a resident is assumed to drill a well to the upper aquifer at one of those locations. The maximum measured soil concentration (surface or subsurface) was used for each of the organic contaminants of concern. For comparison, leaching was also modeled for the 30-ha (70-acre) off-site background location with UL_{95} values for chemicals and average concentrations for radionuclides in local soil.

Leaching of soil contaminants to groundwater was estimated by coupling calculations for the unsaturated and saturated zones and accounting for a site-estimated infiltration rate, the

lateral extent of contaminated soil, horizontal and vertical flow rates, and an aquifer dilution factor. Two different values were used for the rate of infiltration through site soil. A value of 5 cm/yr (2 in./yr) was based on a preliminary estimate for the region by the U.S. Geological Survey, and a value of 13 cm/yr (5 in./yr) was based on a preliminary water balance study for the site (Jones 1990). Values for parameters such as hydraulic conductivity and distribution coefficients were derived from site-specific data and from the literature, and the different types of overburden material present were considered. Values used for these and other parameters are indicated in the following discussion.

The equations and methodology used to predict contaminant concentrations in groundwater from soil leaching are as follows:

$$C_{wi} = \frac{C_{si}}{K_d \times D_f} \qquad \text{(E.1)}$$

where:

C_{wi} = concentration of contaminant i in groundwater (pCi/L for radionuclides, mg/L for chemicals);

C_{si} = soil concentration of contaminant i (pCi/g for radionuclides, mg/g for chemicals);

K_d = distribution coefficient for contaminant i (L/g); and

D_f = dilution factor between the unsaturated and saturated zones (unitless).

The dilution factor is determined from the relationship:

$$D_f = \frac{V_d \times T \times CF}{I \times X_l \times \Phi_v} + 1 \qquad \text{(E.2)}$$

where:

V_d = Darcy velocity in the saturated zone (cm/s);

T = thickness of the saturated zone (m);

CF = conversion factor (3.2×10^7 s/yr);

I = infiltration rate (cm/yr);

X_l = length of the contaminated zone parallel to the direction of groundwater flow (m); and

Φ_v = effective porosity of the unsaturated zone (m^3/m^3).

The Darcy velocity in the saturated zone is determined from the relationship $V_d = K \times \nabla h$, where K = hydraulic conductivity of the saturated zone (cm/s) and ∇h = hydraulic gradient of the saturated zone (m/m).

For these preliminary calculations, the thickness of the unconfined, saturated aquifer was assumed to be 7.6 m (25 ft); a value of 3.8 m/d (12.5 ft/d) was assumed for the hydraulic conductivity; a value of 0.02 was used for the hydraulic gradient; and a value of 0.3 was taken from the literature to represent the effective porosity of unconsolidated soil (Freeze and Cherry 1979). The length used for the contaminated zone parallel to the natural groundwater flow varied according to the specific analysis. A length of 760 m (2,500 ft) was assumed for the sitewide analysis, and a length of 46 m (150 ft) was assumed for the analysis of individual boreholes for the off-site background location. The K_d values were estimated from site-specific information and from the literature; these values are listed in Table E.1 of the BA.

The groundwater concentrations estimated from these calculations are conservative because the level of soil contamination was not assumed to decrease over time and the concentration in the aquifer was identified for a point directly below the contaminated zone (i.e., the path length to the receptor was assumed to be zero). In addition, the initial leaching was assumed to occur as an equilibrium process, with the rate of desorption from soil to water equal to the rate of sorption. The concentration in the saturated aquifer was approximated by assuming that the contaminated water would mix instantaneously and homogeneously with uncontaminated groundwater.

The leaching calculations are independent of time and simply indicate the concentration in groundwater that might eventually occur. To incorporate the time factor, breakthrough times at which contaminants could reach the water table were approximated by applying the approach of Gilbert et al. (1989), with representative values determined from hydrogeological information for the site to reflect potential sorption processes in the overburden material. For these calculations, the contaminant was assumed to move through the unsaturated zone to the water table as a slug, with retardation of the transport velocity occurring as a result of sorption processes along the flow path.

The predicted exposure point concentrations of radioactive and chemical contaminants in groundwater from soil leaching were used to calculate intakes from ingestion of drinking water. The intakes were estimated with Equations 3.12 and 3.13 of the BA, and the risks and hazard indexes estimated from this intake are discussed in Section E.4.2.

In conjunction with estimating the leaching of radionuclides from soil to groundwater, the amount of radon in groundwater that could result from leaching was also assessed. This groundwater concentration was calculated by adding the estimated (leached) concentration of radium-226 in groundwater (assuming secular equilibrium) with the concentration of radon-222

in groundwater produced from radium-226 in soil at the soil-water interface. Because the distribution of radium-226 in the soil column is unknown and difficult to predict, it was conservatively assumed that the concentration of radium-226 in soil at the soil-water interface would be equal to the concentration of radium-226 in the contaminated zone from which it had leached. The equilibrium radon concentration in the pore space was calculated as follows:

$$C_{Rn} = \frac{(C_{Ra} \times \rho \times E)}{P} \qquad \text{(E.3)}$$

where:

C_{Rn} = equilibrium concentration of radon-222 in the pore space (pCi/cm^3);

C_{Ra} = concentration of radium-226 in soil (pCi/g);

ρ = bulk density of soil (assumed to be 1.9 g/cm^3);

E = emanation coefficient (assumed to be 0.4); and

P = soil porosity (assumed to be 0.45).

The concentration of radon in groundwater was then calculated by dividing the equilibrium concentration of radon in the soil pore space by the dilution factor used in Equation E.1. This methodology for calculating the amount of radon in groundwater is very conservative and is intended as only a preliminary estimate. This estimate will be further refined in the forthcoming documentation for the groundwater operable unit, after additional information on subsurface characteristics and groundwater quality becomes available.

The predicted exposure point concentration for radon-222 in groundwater was used to estimate potential impacts from drinking water ingestion and inhalation; the inhalation concentration was based on the contribution to radon-222 in indoor air from volatilization. It was estimated that the concentration of radon in indoor air (pCi/L of air) following volatilization from well water would be 0.01% of the initial concentration in the water (pCi/L of water) (Milvy and Cothern 1990). The results of this preliminary assessment are presented in Section E.4.2.1.

Other than radon gas, the preliminary assessment for groundwater does not address the release of contaminants to indoor air because volatile compounds are not expected to be present. The potential contribution to indoor exposures of radon as a result of volatilization from groundwater is addressed in the discussion of inhalation of indoor air (Section E.4.1.3).

E.4.2 Characterization of Health Effects

Carcinogenic risks from hypothetical radiological and chemical exposures at the site were assessed in terms of the increased probability that an individual would develop cancer over

a lifetime. The EPA has indicated that, for known or suspected carcinogens, acceptable exposure levels for a member of the general public associated with sites on the National Priorities List (NPL) are generally concentration levels that represent an excess upper bound lifetime cancer risk of between 1×10^{-6} (1 in 1 million) and 1×10^{-4} (1 in 10,000) (EPA 1990). This range is referred to as the target risk range in the following discussion and is used as a point of reference for discussing the results of the carcinogenic risk assessment for the site. Identifying a risk as being within this range does not exclude it from further consideration relative to forthcoming cleanup decisions. The final remedial action goals for the site will be determined from various analyses in the RI/FS-EIS, including the preliminary application of DOE's as low as reasonably achievable (ALARA) process for reducing exposures and risks, which is discussed in Chapter 2.

The potential for health effects other than cancer from possible exposures to site contaminants was also assessed. The quantitative measures of noncarcinogenic health effects are the hazard quotient and hazard index. In general, a hazard quotient or an endpoint-specific hazard index greater than 1 indicates the potential for noncarcinogenic health effects. Conversely, a level of 1 or less is considered to indicate a nonhazardous situation.

The methodology used to characterize radiological risks, chemical risks, and hazard indexes is described in detail in Section 5.1 of the BA. The estimated health effects are presented separately for the radiological and chemical analyses in Sections E.4.2.1 and E.4.2.2 of this appendix.

E.4.2.1 Radiological Risks

The radiological risks from external gamma irradiation, inhalation of airborne contaminants generated from site soil, and incidental ingestion of soil are shown in Table E.9. The contributions of individual contaminants to each pathway are shown in Table E.10. Of the three soil-related exposures, inhalation poses the greatest risk to each receptor; essentially all of the inhalation risk comes from radon-222 decay products. The incremental inhalation risks for the recreational visitor and farmer are 5×10^{-5} and 1×10^{-2}. The incremental risk for the ranger varies from 5×10^{-4} to 1×10^{-2}, with a median of 5×10^{-4}; and that for the resident ranges from 6×10^{-7} to 8×10^{-2}, with a median of 2×10^{-5}. (Because outdoor exposures for the ranger are estimated on a sitewide basis and tend to be much higher than the location-specific risks at most locations, the median value and the low end of the range are comparable.)

Only the inhalation risk for the recreational visitor is within EPA's target range because all of the recreational visitor's exposures are outdoors (i.e., indoor radon is not a pathway of concern) and the amount of time that the visitor is exposed to contamination is less than that of the other three receptors. The inhalation risk for the resident and farmer is essentially all from indoor radon-222 decay products, which account for about 90% of the combined risk from indoor and outdoor exposures for the resident (averaged over all boreholes) and about 80% for the farmer at the Ash Pond area. Inhalation risks for the resident are higher at many locations than those for the farmer because the resident spends more time indoors, so the impact of indoor radon-222 decay products is greater. The locations at which inhalation risks for the ranger and the resident exceed the target range are those at which high concentrations of radium-226 in site

soil were either measured or derived from the radiological source term analysis. These risks are probably overestimated by at least a factor of 2 because the conservatively biased source term analysis was used to derive radium concentrations at about 70% of the borehole locations (see Section 5.2.3.1 of the BA).

For the ranger, outdoor radon is the major contributor to the inhalation risk because outdoor exposures were calculated from the sitewide UL_{95} for radium-226. This sitewide value is biased high because the majority of radium-226 measurements were taken from areas with elevated external gamma measurements. The incremental risk from inhalation of outdoor radon-222 decay products for this receptor is estimated to be 5×10^{-4}. This risk is also probably overestimated by a factor of 2 or more as a result of the biased sampling strategy used to obtain the radium-226 concentration in surface soil.

In fact, radon represents a special case that was not explicitly accounted for in the development of EPA's target risk range for NPL sites, and the EPA has identified a separate health-based level for this contaminant. (The concentration of radon in indoor air that is considered acceptable by EPA is 4 pCi/L [EPA 1992].) Compared with the target risk range, relatively high risks are associated with naturally occurring levels of radon. For example, the EPA has estimated that the lifetime risk from inhaling background levels of radon-222 and its short-lived decay products is about 1×10^{-2} (EPA 1989c). The risks estimated for the recreational visitor, ranger, resident, and farmer from radon inhalation can be compared with the risk from exposure to ambient levels by using the same exposure assumptions with the background value of 1.2 pCi/g for radium-226; the risks associated with inhalation of radon at a background location are 5×10^{-6} for the recreational visitor, 3×10^{-4} for the ranger, and 2×10^{-3} for both the resident and farmer.

The total risks from incidental ingestion of soil are much lower than the incremental risks from inhalation. In most cases, lead-210 is the primary contributor. The total risks estimated for the recreational visitor and farmer are 8×10^{-6} and 4×10^{-4}, respectively; these values also represent the incremental risks for those receptors. For the ranger, the total ingestion risk is 9×10^{-5}, and the incremental risk is 8×10^{-5}. The total risk for the resident ranges from 5×10^{-7} to 3×10^{-3}, with a median of 1×10^{-5}; the incremental risk ranges from 0 (background) to 3×10^{-3}. Although the total and incremental risks for the recreational visitor and ranger are less than 1×10^{-4}, the incremental risks exceed this level for the farmer at the Ash Pond area and for the resident at 44 locations. The ingestion risks for the ranger, resident, and farmer can be compared with the risks for these receptors at a background location by using the same exposure assumptions with background concentrations of the radionuclides (i.e., 1.2 pCi/g for radionuclides in the uranium-238 and thorium-232 decay series and 0.055 pCi/g for radionuclides in the uranium-235 decay series). The ingestion risks associated with background levels of these radionuclides for the recreational visitor, ranger, resident, and farmer are 8×10^{-7}, 8×10^{-6}, 1×10^{-5}, and 2×10^{-5}, respectively.

The incremental risks from external gamma irradiation are relatively small for each receptor compared with those from inhalation, and they exhibit the least variation of all soil-related risks. The incremental risks for the recreational visitor and farmer are 4×10^{-6} and

3×10^{-5}, respectively. The ranger's risks vary between 4×10^{-5} and 6×10^{-4}, with a median of 5×10^{-5}. For the resident, the incremental risk ranges from 0 (background) to 6×10^{-3}, with a median of 2×10^{-4}. These estimates for on-site exposures can be compared with the risk from background external gamma irradiation by using the same exposure assumptions with the local background value of 10 μR/h; the associated risk is 1×10^{-5} for the recreational visitor, 2×10^{-4} for the ranger, and 1×10^{-3} for both the resident and farmer.

The total risks from external gamma irradiation, incidental ingestion, and inhalation combined are summed in Table E.9. The total risk is 6×10^{-5} for the recreational visitor and 1×10^{-2} for the farmer. For the ranger, this risk varies from 6×10^{-4} to 1×10^{-2}, with a median of 7×10^{-4}. For the resident, the risk ranges from 1×10^{-6} to 9×10^{-2}, with a median of 2×10^{-4} (Figure E.2). Because the incremental risk from inhalation of radon-222 decay products dominates the total combined risk, this estimate essentially represents those results. For comparison, the combined risk for external gamma irradiation, incidental ingestion, and inhalation at the background location is 2×10^{-5} for the recreational visitor, 5×10^{-4} for the ranger, and 3×10^{-3} for both the resident and farmer. As indicated by Figure E.2, the incremental risk for the resident from these combined exposures exceeds both the target range and the background risk at many locations.

In addition to the exposures to soil and air common to all receptors, ingestion of homegrown food (garden produce and beef and dairy products) was evaluated for the farmer. Radionuclide-specific doses and risks estimated for this exposure are given in Table E.11. The total radiological risk to the farmer from ingesting homegrown food is 7×10^{-4}, and lead-210 is the primary contributor. For comparison, the radiological risk estimated for the farmer at the off-site background location with the same exposure assumptions is 5×10^{-5}. The uncertainty associated with the food ingestion pathway is high because biouptake data for the site are limited and very little information is available in the literature from which to determine appropriate plant uptake and animal biotransfer factors for each contaminant under site-specific conditions. Therefore, results have been presented separately for this pathway and compared with background estimates to indicate relative impacts. To also provide an estimate of reasonable maximum exposures, results for the ingestion of homegrown food are summed with the results for inhalation, incidental ingestion of soil, and external gamma irradiation for the farmer in the summary presentation (Section E.6.2). Ingestion of fish and game could also be included for each receptor, and those results are given in Sections 5.2.4.1 and 5.3.2.1 of the BA (DOE 1992a). The incremental risk estimated for ingesting fish and game would be within or below EPA's target range.

Results for potential groundwater exposures in this rebaseline assessment are considered preliminary because the available hydrogeological data on which the estimates were based are limited. The contaminated groundwater in the shallow (Burlington-Keokuk Limestone) aquifer at the site is not currently used as a drinking water supply. Groundwater is being addressed as a separate operable unit of the overall site remediation process because more information is needed to support final cleanup decisions. The hydrogeology at the site will be further characterized over the next several years to support an expanded evaluation of groundwater, which will include an assessment of exposures combined across all reasonable pathways. For

these reasons, the screening-level results for groundwater ingestion are not summed with the other basic pathways at the current stage of the assessment process. To assess current risks for the hypothetical resident from drinking water ingestion, radiological exposures were estimated from contoured concentrations of uranium in groundwater beneath each soil borehole. (Uranium is the only radionuclide that has been detected in site groundwater at concentrations elevated above background.) To predict future risks, the contaminant concentrations in groundwater were estimated from leaching calculations for site soil. The results of these two analyses are shown in Table E.12. To put the results in perspective, the total risk associated with EPA's proposed drinking water standards for radionuclides (EPA 1991b) was calculated with the same exposure parameters that were used in this assessment. The total risk associated with the proposed maximum contaminant levels is 1×10^{-3}, and radium accounts for almost 80%.

Results of the leaching analyses indicate that lead-210 is the major contributor to the risk associated with drinking groundwater under predicted future conditions, both on-site and at the off-site background location. These calculations do not incorporate a time factor, so the contaminant-specific results cannot be directly summed to estimate a total risk. If time were also considered, these fairly immobile contaminants with K_d values greater than 100 (see Table E.1 of the BA) would not be expected to reach the unconfined groundwater aquifer for more than 10,000 years as a result of nonpreferential leaching through the unconsolidated overburden material (Figure E.3). For those instances in which a preferential pathway might be established, this transport time would be shorter.

Conservative estimates of future radon-222 concentrations in groundwater that could result from radium-226 leaching through the soil column for an infiltration rate of 5 cm/yr (2 in./yr) are 970 and 105 pCi/L for the on-site resident and the resident at the background location, respectively. The corresponding concentrations for an infiltration rate of 13 cm/yr (5 in./yr) are 2,200 and 240 pCi/L. These estimates were calculated by applying Equation E.3 to determine the equilibrium radon concentration in the pore space at the soil-water interface and then dividing by the dilution factor used in Equation E.1 to obtain the radon concentration in groundwater. A resident could be exposed to radon-222 in groundwater directly by ingestion of drinking water and indirectly by inhalation of indoor air to which radon has volatilized, e.g., from well water used for cooking, laundering, and showering. At an assumed soil infiltration rate of 5 cm/yr (2 in./yr), the risk for the on-site resident from inhalation is estimated to be 2×10^{-4}; the risk associated with an infiltration rate of 13 cm/yr (5 in./yr) would be 4×10^{-4}. These risks are largely due to inhalation; the radiological risk from ingestion of radon in drinking water is estimated to be about 20% of that from inhalation (Mills 1990). For comparison, the risk estimated for an off-site background resident would be 2×10^{-5} for an infiltration rate of 5 cm/yr (2 in./yr), which is about 1% of the risk estimated for the resident from indoor radon-222 emanating directly from soil.

This initial analysis of drinking water ingestion is considered very preliminary because location-specific chemical and hydrogeological data are not available for the entire site. The assessment will be refined in forthcoming documentation for the groundwater operable unit after additional data become available.

Results of the location-specific analysis for the soil redistribution scenario are similar to or less than those for surface soil because the radioactive contamination is largely surficial. Therefore, mixing subsurface soil having little or no contamination with surficially contaminated soil and redistributing this mixture on the surface would result in a lower concentration of radionuclides in the new surface soil to which the resident could be exposed. In addition, the risk associated with indoor radon — which is a major component of the radiological risk at most locations — would be the same as that estimated for existing conditions because the emanation of radon from radium at depth was incorporated in the calculations. Although the concentrations of certain radionuclides are higher in subsurface soil than surface soil at a number of locations, the concentration averaged over 3 m (10 ft) is less than or comparable to the surficial concentrations at all but 11 locations. Three are in the immediate vicinity of the raffinate pits, three are in the Ash Pond/South Dump Area, four are in the general vicinity of former process buildings, and one is at the southern end of the site. The radiological risk to the resident at these locations would be about 2 or 3 times higher than estimates for the basic scenario, but the overall results across the site do not differ significantly. These areas of subsurface contamination were considered in the development of cleanup criteria for site soil (Chapter 2). At these locations, the relatively high concentration of uranium to depths of up to 3 m (10 ft) is the primary contributor to the higher risks.

E.4.2.2 Chemical Health Effects

The chemical carcinogenic risks and hazard indexes from incidental ingestion of site soil and inhalation of airborne contaminants generated from soil are shown in Table E.13. The pathway-specific risks and hazard quotients for the individual contaminants are indicated in Tables E.14 and E.15, respectively.

The total combined risks from incidental ingestion and inhalation are 2×10^{-6} for the recreational visitor, 2×10^{-5} for the ranger, and 5×10^{-5} for the farmer. In contrast to the radiological results, the inhalation risk is less than 4% of the total risk for all receptors, so the combined risk is essentially represented by that from soil ingestion. For the resident, the combined risk ranges from 3×10^{-6} to 6×10^{-4}, with a median of 3×10^{-5}. The risk ranges from 1×10^{-5} to 1×10^{-4} at most locations, and the incremental (and total) risk exceeds 1×10^{-4} at less than 5% of the soil areas (15 locations, Figure E.4). In general, arsenic is the primary contributor to these estimates, although polychlorinated biphenyls (PCBs) contribute significantly at the few locations where they occur. The maximum risk is associated with the single location where carcinogenic polycyclic aromatic hydrocarbons (PAHs) were detected; these compounds account for about 95% of that risk.

The hazard index from incidental ingestion and inhalation combined is 0.02 for the recreational visitor; for the ranger, it varies from 0.3 to 0.5, with a median of 0.4. Therefore, no noncarcinogenic effects are indicated for these two receptors. The combined hazard index for the farmer is 2, and that for the resident ranges from 0.09 to 9, with a median of 0.6; this index exceeds 1 for the resident at 26 locations. For all receptors, both pathways contribute to the total hazard index, although soil ingestion is generally more significant. On the basis of the soil ingestion pathway alone, the hazard index for the resident exceeds 1 at 18 locations. In general,

the primary contributors are uranium, arsenic, and thallium. The inhalation hazard index for the resident exceeds 1 at two locations, and chromium is a key contributor at both locations.

For those locations where the combined hazard index from incidental ingestion and inhalation exceeds 1, the contaminants contributing to this estimate were identified to determine their major health end points (e.g., target organs) in order to segregate the hazard index. (The segregation of hazard index is discussed in Section 5.1.2.2 of the BA.) For 9 of the 26 locations where the resident's combined hazard index exceeds 1, uranium alone accounts for an ingestion hazard index greater than 1. The segregated hazard index exceeds 1 at three other locations because uranium and arsenic are present together at elevated concentrations and both compounds can affect the kidney. At one location, the combined presence of arsenic and thallium results in a segregated hazard index exceeding 1 as a result of potential effects on the skin and hair. Inhalation of chromium accounts for a hazard index greater than 1 at one additional location. The segregated hazard indexes are less than 1 for the remaining 12 locations. Those locations at which the segregated hazard indexes exceed 1 for the resident are shown in Figure E.5. The segregated hazard index for the farmer at the Ash Pond area is less than 1.

For lead, an oral reference dose (RfD) is not available from which to estimate potential noncarcinogenic effects, so exposures were evaluated with a separate approach. The EPA has developed an uptake/biokinetic model to address residential exposures for the most sensitive subpopulation, children aged 0 through 6. The model estimates blood lead levels in children from exposures to lead in soil, air, drinking water, diet, and paint. A blood lead level of less than 10 µg/dL from the various exposures is not considered to be indicative of lead poisoning; levels ranging from 10 to 14 µg/dL are considered to be in the border zone for potential health effects; levels from 15 to 19 µg/dL are considered indicative of risk for decreased IQ (up to several points) and other subtle effects; and the potential for serious health effects increases as levels increase above 20 µg/dL (Centers for Disease Control 1991).

The Missouri Department of Health (1992) considers a lead concentration of 240 mg/kg in soil safe for any use, including for residential settings. This level is exceeded at four surface locations on-site, and high concentrations in subsurface soil at two additional locations result in a 3-m (10-ft) weighted average above this level. (The weighted average targets subsurface contamination and addresses the potential future scenario under which soil is excavated to construct a basement and is then redistributed on the surface as a yard.) These six locations were evaluated with EPA's model. The state level was also separately assessed, with an air concentration derived from the listed soil value and a representative groundwater concentration estimated from all wells in which lead was detected by averaging the measurements over the 4-year sampling period (see Appendix B of the BA).

The following site-specific information was incorporated into the model calculations. Individual borehole measurements for surface soil were used unless lead was only elevated in subsurface soil, in which case the 3-m (10-ft) weighted average was used. The concentration in air was estimated from the soil concentration on a location-specific basis, as described in Section 3.3.4 of the BA. For the drinking water component, groundwater measurements are not available for each soil sampling location. Therefore, concentration contours for lead in

groundwater beneath the site were generated from the limited data available for monitoring wells in the Burlington-Keokuk Limestone aquifer. The lead concentrations in groundwater estimated by this contouring method were then linked with the appropriate soil borehole locations for this preliminary analysis.

The exposure assumptions were the model default values, except as follows. The concentration of lead in indoor dust was conservatively assumed to be the same as that for outdoor soil, and the concentration of lead in indoor air was assumed to be 80% of the concentration in outdoor air. The child was assumed to spend 1 hour per day outdoors, averaged over the year. No contribution was assumed for paint because lead-based paint is no longer used in homes and the hypothetical residence being evaluated would be constructed at some time in the future. The exposure point concentrations and the results of the model calculations are shown in Table E.16. Presented in the table are the geometric mean concentrations of lead in blood for a child aged 0 to 72 months and the percentage of children expected to have blood levels exceeding 10 µg/dL. The EPA has indicated that acceptable lead levels in soil correspond to those for which less than 5% of the population would be expected to exceed blood lead levels of 10 µg/dL.

The results of the model calculations indicate that the blood lead level of 10 µg/dL would be exceeded by greater than 5% of the exposed population at five locations. These locations are in the northern portion of the site, in the general vicinity of Ash Pond. The blood lead level associated with the state soil guideline of 240 mg/kg is 4.3 µg/dL (geometric mean), and less than 0.7% of the population would be expected to have a blood level above 10 µg/dL.

In addition to the exposures to soil and air common to all receptors, ingestion of chemical contaminants in homegrown food (garden produce and beef and dairy products) was evaluated for the farmer, as described for radionuclides. Contaminant-specific chemical risks and hazard indexes estimated for this exposure are given in Tables E.17 and E.18, respectively. The total risk to the farmer from ingesting homegrown food is 2×10^{-4}, and the combined hazard index is 9. The modeled concentration of arsenic in garden produce accounts for essentially all of the ingestion risk, and arsenic and uranium each account for a hazard index greater than 1. For comparison, the risk and hazard index estimated for the farmer at the off-site background location under the same exposure assumptions are generally comparable, i.e., 1×10^{-4} and 3. (Although not obvious from these values because of rounding to one significant figure, the risk estimated for ingestion of garden produce off-site is 70% of that estimated for ingestion on-site, and arsenic is again the dominant contributor.) Thus, model predictions of potential on-site health effects are within a factor of 2 to 3 of those for off-site background. This small difference is well within the range of uncertainty associated with the methodology available for estimating these values. The incremental risk from ingesting homegrown food is less than 1×10^{-4}.

As previously indicated for radionuclides, considerable uncertainty is associated with the model predictions for food ingestion (Section E.4.2.1). Therefore, results have been presented separately for this pathway and compared with background estimates to indicate relative impacts. To also provide an estimate of reasonable maximum exposures for the farmer, results

for the ingestion of homegrown food are summed with the results for inhalation and incidental ingestion of soil in the summary presentation (Section E.6.2). Ingestion of fish and game could also be included for each receptor, and those results are given in Sections 2.4.5.2, 5.2.4.2, and 5.3.2.2 of the BA.

Exposure to chemicals in groundwater via drinking water ingestion was estimated in the same manner as described for radionuclides (Section E.4.2.1). Potential risks and hazard quotients were estimated for the resident under current and predicted future conditions to indicate possible health effects for this additional pathway. The results are shown in Table E.19 (risks) and Table E.20 (hazard quotients). Nitroaromatic compounds and arsenic are the primary contributors to the risk estimated for current contaminant conditions, and nitrate is the primary contributor to the hazard index.

The contaminant-specific results for exposures to future groundwater concentrations predicted from sitewide leaching cannot be directly summed to estimate a total risk or hazard index, because a time factor was not incorporated in these calculations and the contaminants would be expected to reach the shallow aquifer at different times. However, results for the sitewide calculations indicate that the risk and hazard index would be comparable to background levels, i.e., the incremental risk would be within or below the target range. Results of the preliminary leaching calculations for soil at specific locations with subsurface contamination (e.g., nitroaromatic compounds) indicate that future groundwater concentrations could be associated with incremental health effects if a well were constructed at those locations.

The preliminary nature of this assessment cannot be overemphasized. Conservative assumptions were used to estimate groundwater concentrations from current data and considerable uncertainty is inherent in any leaching calculations for field conditions. Additional data will be collected to further define site-specific factors such as K_d values for use in refining these estimates to support future groundwater decisions. Incorporating a time factor in the leaching calculations indicates that fairly immobile contaminants, such as the heavy metals with K_d values greater than 100 (see Table E.1 of the BA), would not be expected to reach the unconfined groundwater aquifer for about 10,000 years as a result of nonpreferential leaching through the unconsolidated overburden material. For those instances in which a preferential pathway might be established, this transport time would be shorter. Mobile contaminants, such as those with a K_d value of 1 or less (e.g., nitrate), could appear in the water table in about 23 years, and contaminants of intermediate mobility (e.g., K_d value of 5) could leach from the soil to groundwater in about 500 years (Figure E.3). As for the radiological assessment of groundwater, the chemical assessment will be refined in documentation to be prepared for the groundwater operable unit after additional data become available.

Results of the location-specific analysis for the soil redistribution scenario indicate that risks and hazard indexes are generally similar to or less than those for surface soil. At a few locations, pockets of relatively high subsurface concentrations of nitroaromatic compounds, arsenic, and uranium are the major sources of elevated risks and hazard indexes. This information was used to support the development of cleanup criteria for site soil (Chapter 2).

E.4.3 Multiple Exposure Pathways

The same recreational visitor could be exposed to contaminated media both on-site and off-site if it were hypothetically assumed that institutional controls disappeared at some point in the future. The radiological risks from exposures to sitewide soil and air are relatively low when directly compared with those for the Southeast Drainage, assuming that all of the time spent in off-site areas over the 30 years is spent at those specific locations in the drainage with elevated radioactivity. Thus, the total radiological risk for a future recreational visitor to the area would range from the estimate of 6×10^{-5} for the site to the preliminary estimate of 2×10^{-4} for the drainage. (For comparison, the risk estimated for a recreational visitor from the same exposures at a background location is 2×10^{-5}.)

The total chemical risk from sitewide exposures is 2×10^{-6}; this is the same as that estimated for the Southeast Drainage, assuming all exposures occur at that location. Under the same assumption, chemical risks for Burgermeister Spring and Lakes 34, 35, and 36 are 9×10^{-7} and 4×10^{-6}, respectively. Each of these risks is within or below EPA's target levels. Results for the noncarcinogenic health effects indicate that the hazard index from sitewide exposure to soil and air is much less than 1, as is the index from exposures at each of the off-site areas. Likely estimates of future risks and hazard indexes would be bounded by these projections, as appropriate to the specific activities of the individual and the relative time spent at any one location.

The recreational visitor, ranger, resident, or farmer might also fish at the off-site lakes or hunt on-site. Potential health effects were estimated for fish taken from Lakes 34, 35, and 36 (Section 5.3.2 of the BA) and game taken from the site (Section 5.2.4 of the BA). In addition to the estimated ingestion exposure, an individual fishing or hunting would incur exposures similar to those estimated for the recreational visitor at the lakes (exposure to surface water and sediment/shoreline soil) and at the site (exposure to soil and air). The reasonable maximum exposure for an avid sportsman was estimated for an individual who both fishes and hunts in the area by combining results for these varied exposure pathways. The total radiological and chemical risks estimated for this individual are 5×10^{-5} and 3×10^{-6}, and the hazard index is 0.08 (Section 5.4.2 of the BA). These estimates could be summed with those for the receptors evaluated in this long-term assessment if it were assumed that each of the pathways could reasonably be combined for a maximally exposed individual. Incremental risks associated with the sportsman's exposures would be within or below EPA's target range.

E.5 UNCERTAINTY IN THE RISK ASSESSMENT PROCESS

The evaluation of impacts to human health in this rebaseline assessment was based, by necessity, on a number of site-specific assumptions. In addition, many uncertainties are inherent to the risk assessment process. The impacts of the various uncertainties and assumptions on the risks and hazard indexes estimated in this rebaseline assessment for possible future exposures at the site are the same as those discussed in detail in Sections 5.5.2 and 5.6 of the BA; hence, the discussion is not repeated here. Similarly, although ingestion of garden produce, beef, and dairy products was not specifically addressed in the BA, the uncertainties associated with these

pathways are as described for plant uptake and animal biotransfer for the game ingestion pathway in Section 5.6.2.1 of the BA. Hence, the following discussion of uncertainties focuses on the single pathway that is specific to the rebaseline assessment, ingestion of groundwater.

Considerable uncertainty is associated with the health effects estimated for drinking groundwater from the shallow (Burlington-Keokuk Limestone) aquifer in this assessment. In fact, the groundwater most likely to be tapped for a drinking water source at the site would be the deep, productive aquifer in the St. Peter Sandstone. On the basis of the very limited data available for that aquifer, it does not appear to be contaminated. Thus, even if the well were not screened to preclude inflow from the upper aquifer, the concentrations in drinking water that would be ingested would probably be lower than those evaluated in this assessment because it would mix with water drawn from the deeper aquifer.

The primary limitation in the current exposure point concentrations used for the preliminary groundwater analysis is the unavailability of comprehensive data, as described in Appendix B of the BA. Monitoring wells are at scattered locations across the site because of access constraints imposed by man-made features such as the raffinate pits and buildings. In addition, these wells extend to different depths so it is difficult to construct an integrated picture of groundwater contamination in the shallow aquifer at this time. Furthermore, only a small number of measurements are available for certain contaminants and/or wells, and the variability in contaminant measurements is high — in certain cases reflecting factors associated with the analysis, such as sample preservation, holding times, and detection limits.

The information currently available for groundwater contamination was used to generate contours that were extended beneath the entire site so location-specific exposure point concentrations could be interpolated. (For this effort, samples reported as nondetects for metals and inorganic anions were replaced with half the detection limit.) Thus, risks and hazard indexes were estimated from derived values rather than actual measured values at essentially all borehole locations. These factors contribute to the substantial uncertainty in the results and limit the conclusions that can be made at this time. Removal of the constraining site features pursuant to a decision for the current remedial action would permit the collection of more comprehensive data over the next several years to address existing data gaps. These data would be used to prepare an expanded assessment of groundwater to support final decisions for the site.

Compared with the effect of data limitations on estimates for current exposure point concentrations, a larger uncertainty is associated with the future exposure point concentrations estimated for the groundwater analysis. Those values were determined from leaching calculations, considering the contaminant concentrations in soil. The conservative approach used to estimate these groundwater concentrations does not account for a gradual decrease in the soil concentration over time or for any dispersion or adsorption within the aquifer, and the path length to the hypothetical receptor was assumed to be zero. In addition, the initial leaching was assumed to occur as an equilibrium process, with the rate of desorption from soil to water equal to the rate of sorption; various sorption studies have indicated that this is a conservative assumption.

A key parameter in these calculations is the contaminant-specific distribution coefficient or K_d, which is a measure of the amount of a contaminant associated with soil compared to the amount in solution. This coefficient is strongly dependent on site-specific conditions, but data from which to select appropriate K_d values for site contaminants are very limited. In the absence of such information, data from the literature, including empirical equations, were used to derive preliminary estimates of these values. The fraction of organic carbon in soil used for the equations was conservatively taken from the low end of the range measured for the site. Conservative values were also used for other parameters such as hydraulic conductivity, the hydraulic gradient, and effective porosity. The use of conservative assumptions for each parameter in the calculations results in considerable uncertainty and a very conservative bias in the risk estimates.

Finally, although a time factor was incorporated in the leaching calculations for the groundwater analysis to consider potential adsorption by the overburden material, the breakthrough time cannot be confidently predicted for each contaminant because of the great uncertainty in the K_d values and the spatial variability in subsurface conditions across the site. Therefore, it is difficult to address temporal and spatial variability to appropriately sum individual risks and hazard quotients and estimate the total risk and hazard index for this pathway. In summary, the large uncertainty in the preliminary groundwater assessment reflects the limitations in information currently available. The results will be applied to focus additional characterization efforts, and the new data will be used to refine these estimates in documentation for the groundwater operable unit to be prepared within the next several years.

E.6 SUMMARY OF THE REBASELINE HEALTH ASSESSMENT

E.6.1 Short-Term Assessment of the Interim Site Configuration

The short-term rebaseline assessment addresses impacts associated with new site conditions resulting from interim actions; it evaluates exposures over the next 10 years, assuming that institutional controls are maintained. The exposure assessment and resulting health effects associated with rebaseline conditions are generally similar to those presented for the short-term assessment in the BA (DOE 1992a). Exposures estimated for an additional on-site worker conducting maintenance activities at the new facilities, as represented by the TSA (which would include the containerized process waste from water treatment plant operations), would be slightly lower than those presented in the BA for the routine maintenance worker. The risk for this new worker from external gamma radiation would be about three times higher than for the worker conducting general site maintenance activities under the baseline conditions. However, the time required to conduct periodic maintenance activities at the new facilities would be less than that for routine maintenance activities. Incorporating the contribution from exposures to sitewide soil and air, the total radiological risk for the additional worker at the new facilities would be about 20% of that estimated for the baseline maintenance worker.

Potential impacts to the trespasser would decrease considerably under new site conditions, to less than 2% of those estimated for baseline conditions. This estimate assumes that

exposures at the buildings and raffinate pits would no longer occur. For the off-site recreational visitor, the incremental impact associated with ingesting treatment plant effluent from the Southeast Drainage would not change overall radiological risks estimated for this location under baseline conditions. The total chemical risks could increase by a factor of 4, whereas the estimated potential for noncarcinogenic effects would not change. Therefore, despite the potential for a small increase in chemical risks at this location, overall chemical health effects for the recreational visitor would remain generally the same. Furthermore, the effluent will probably not be discharged to the drainage because under a recent change in plans, the treated water is to be released to the Missouri River through a buried pipeline (Section 1.5.1.4). In summary, the overall short-term impacts under interim site conditions are expected to be comparable to or somewhat less than those presented in the BA.

E.6.2 Long-Term Assessment of the Interim Site Configuration

For the long-term assessment of the interim site conditions, institutional controls were assumed to be lost after the interim actions were fully implemented. For this assessment, impacts to an on-site recreational visitor were assessed to determine what changes might result from exposures at the newly constructed (temporary) facilities. (The recreational visitor was also evaluated for the long-term assessment under baseline conditions [DOE 1992a]). Risks associated with the buildings account for about 35% of the radiological risk under baseline conditions when exposures are assumed to be equally distributed between the buildings, raffinate pits, and sitewide soil and air. Exposures at the raffinate pits account for most of the remainder. For these same exposures, more than 95% of the chemical risk and hazard index is associated with the buildings. Because exposures in the buildings would no longer be relevant after dismantlement, total radiological and chemical risks would be substantially lower under the new site conditions. In addition, the potential for noncarcinogenic effects would no longer exist because the hazard index from sitewide exposures is much less than 1.

Although exposures within the buildings would no longer occur, the recreational visitor could be exposed to building material and other debris at or dispersed from the TSA or MSA. However, the contribution from radon decay products, which account for about 30% of the radiological risk estimated for exposures in the buildings, would not be relevant under these conditions. Potential exposures to material from the quarry that would be stored at the TSA could result in noncarcinogenic health effects and radiological and chemical carcinogenic risks similar to those identified in the BA for other (nonbuilding) exposures on-site. These changes are expected to essentially balance each other so that overall impacts to the recreational visitor under interim site conditions would be comparable to those estimated under baseline conditions.

E.6.3 Long-Term Assessment of the Modified Site Configuration

The long-term assessment of the modified site configuration addresses possible exposures in the extended future after institutional controls at the site are assumed to be lost. For this assessment, the temporary facilities are "set aside" in order to focus on soil-related exposures. Health impacts from exposures to soil and air were estimated for a recreational

visitor, ranger, resident, and farmer. The results indicate that radiological risks for the ranger, resident, and farmer would exceed EPA's target risk range over about 50% of the site. Similarly, the chemical risk and hazard index would exceed the target levels for the farmer and also for the resident at certain locations (less than 5% of the site). Radiological risks result primarily from inhalation of radon-222 and its short-lived decay products, whereas chemical risks and hazard indexes result primarily from incidental ingestion of arsenic and organic compounds (PCBs and PAHs) in soil. The results of the long-term assessment are summarized in Table E.21. The results for ingestion of homegrown food by the farmer are also included in this table.

The combined carcinogenic risks from exposures to the radionuclides and chemical carcinogens in site soil are also shown for each receptor in Table E.21. Considerable uncertainty is associated with summing these estimates because assumptions inherent in the methods available for calculating radiological and chemical risks differ and their sum does not account for potential antagonistic or synergistic effects. As a lesser factor, soil was sampled at different locations for the radioactive and chemical contaminants, so the results determined for the ranger and the resident at individual boreholes are not at exactly the same locations. To address this issue, a weighted inverse-distance squared approach was used to combine the radiological and chemical risk estimates (as described in Section 3.3.1.2 of the BA).

Exposures from drinking water ingestion estimated for both current and predicted future conditions were also evaluated in a preliminary analysis to indicate potential concerns and focus upcoming characterization efforts. Results of this preliminary assessment indicate that health effects from long-term exposures might occur at a number of locations on-site if a well were drilled directly into the shallow aquifer at those specific locations. The results are considered preliminary for a number of reasons (Section E.5), and the analysis will be refined within the next several years as more data become available.

Excluding the food ingestion pathway, radiological risks are higher than chemical risks for each receptor at most locations, and radon is the main contributor. Therefore, the combined risks are essentially represented by the radiological risks. For this reason, the uncertainty associated with summing the risk estimates for the basic exposure pathways does not affect the overall result. This outcome reflects the nature of soil contamination at the site, i.e., concentrations of metals are generally at background levels and organic compounds are present at only a few locations, whereas radioactive contamination is more widespread and related risks are naturally higher. That is, although the levels of radioactive contamination at non-source areas are generally low, even background levels of these naturally occurring metals result in risks above the target range. Together with the results of the BA (DOE 1992a), the information presented in this appendix was used to focus remaining cleanup decisions and support the development of cleanup criteria for site soil, which are presented in Chapter 2.

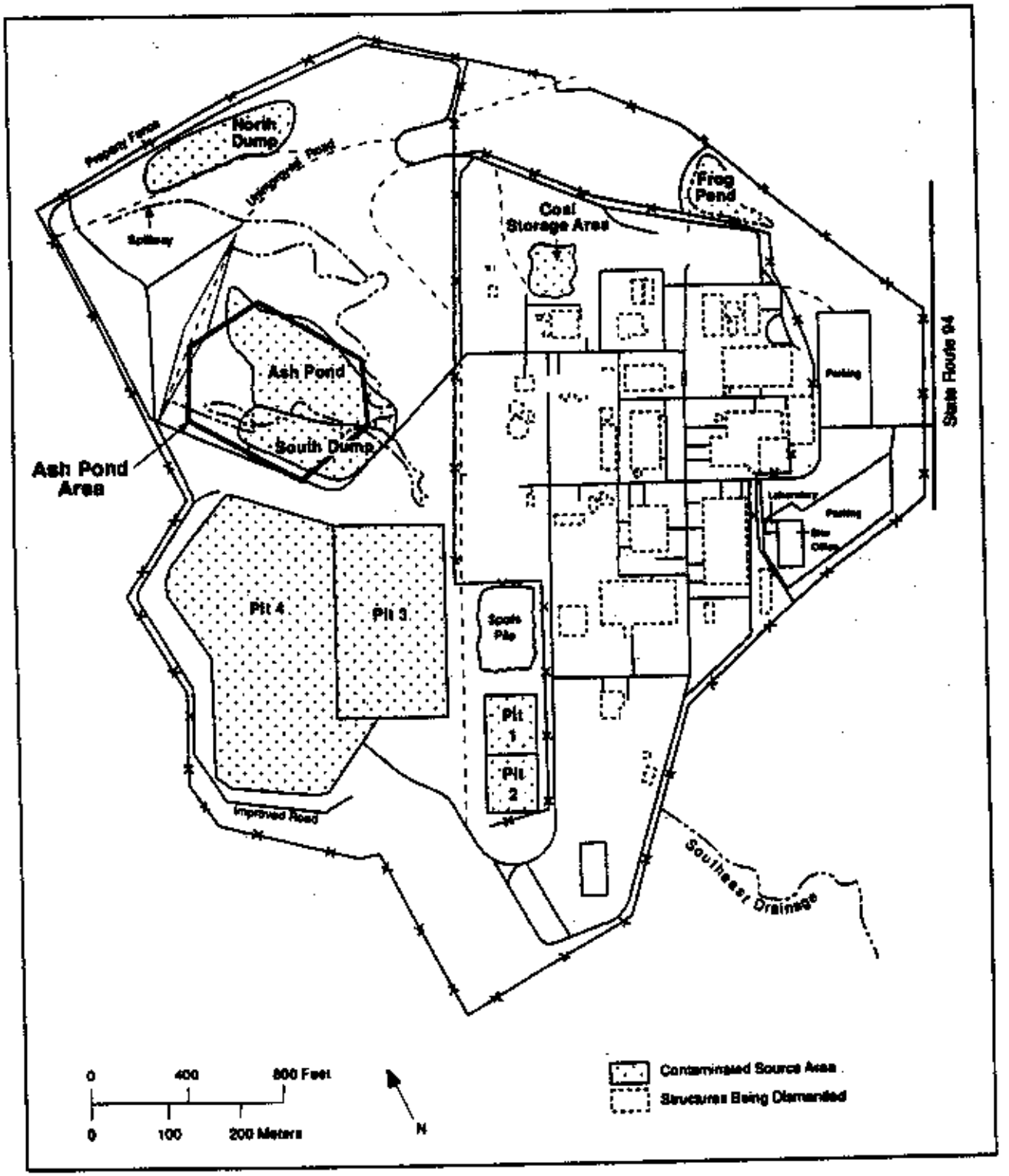

FIGURE E.1 Location of the Ash Pond Area for the Farmer Analysis

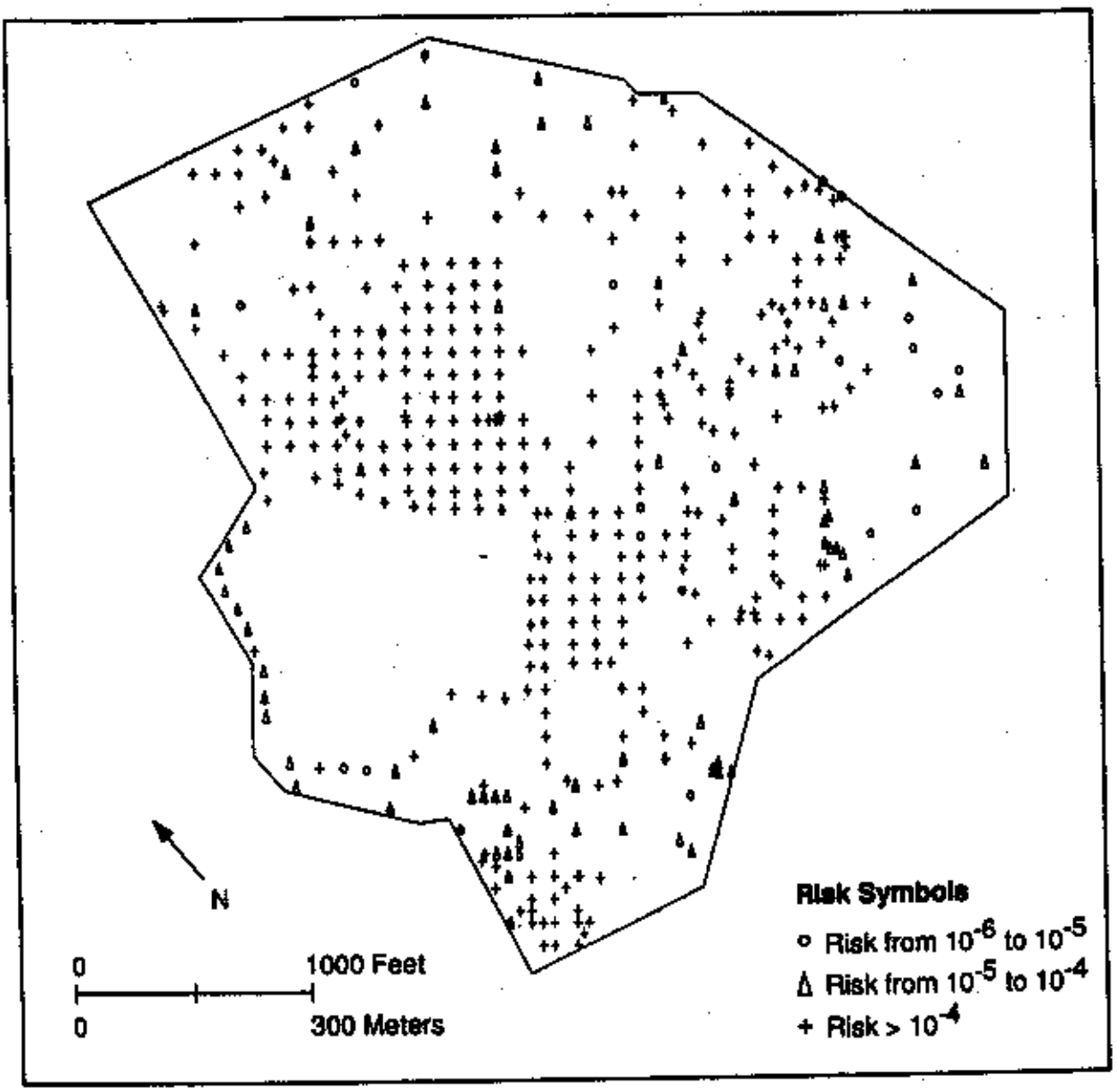

FIGURE E.2 Location-Specific Radiological Risks for the Hypothetical Resident

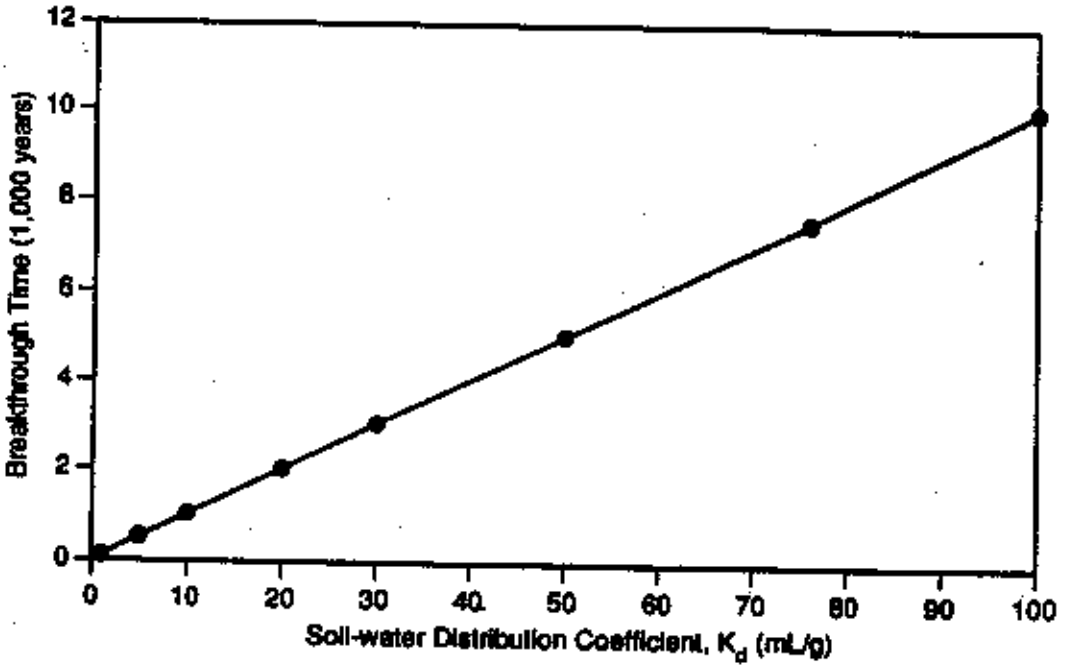

FIGURE E.3 Estimated Breakthrough Times as a Function of K_d for Contaminant Leaching to Groundwater

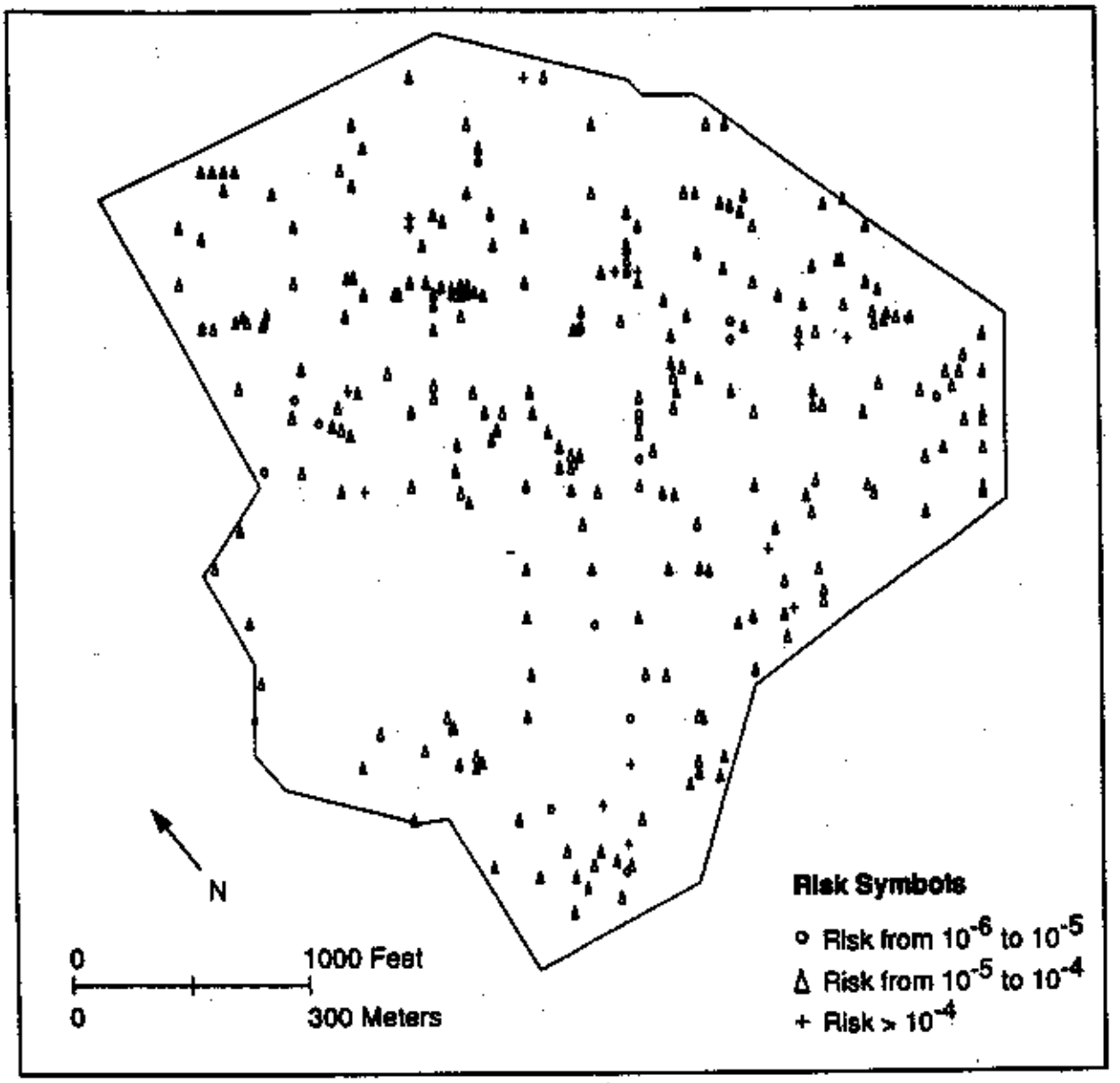

FIGURE E.4 Location-Specific Chemical Carcinogenic Risks for the Hypothetical Resident

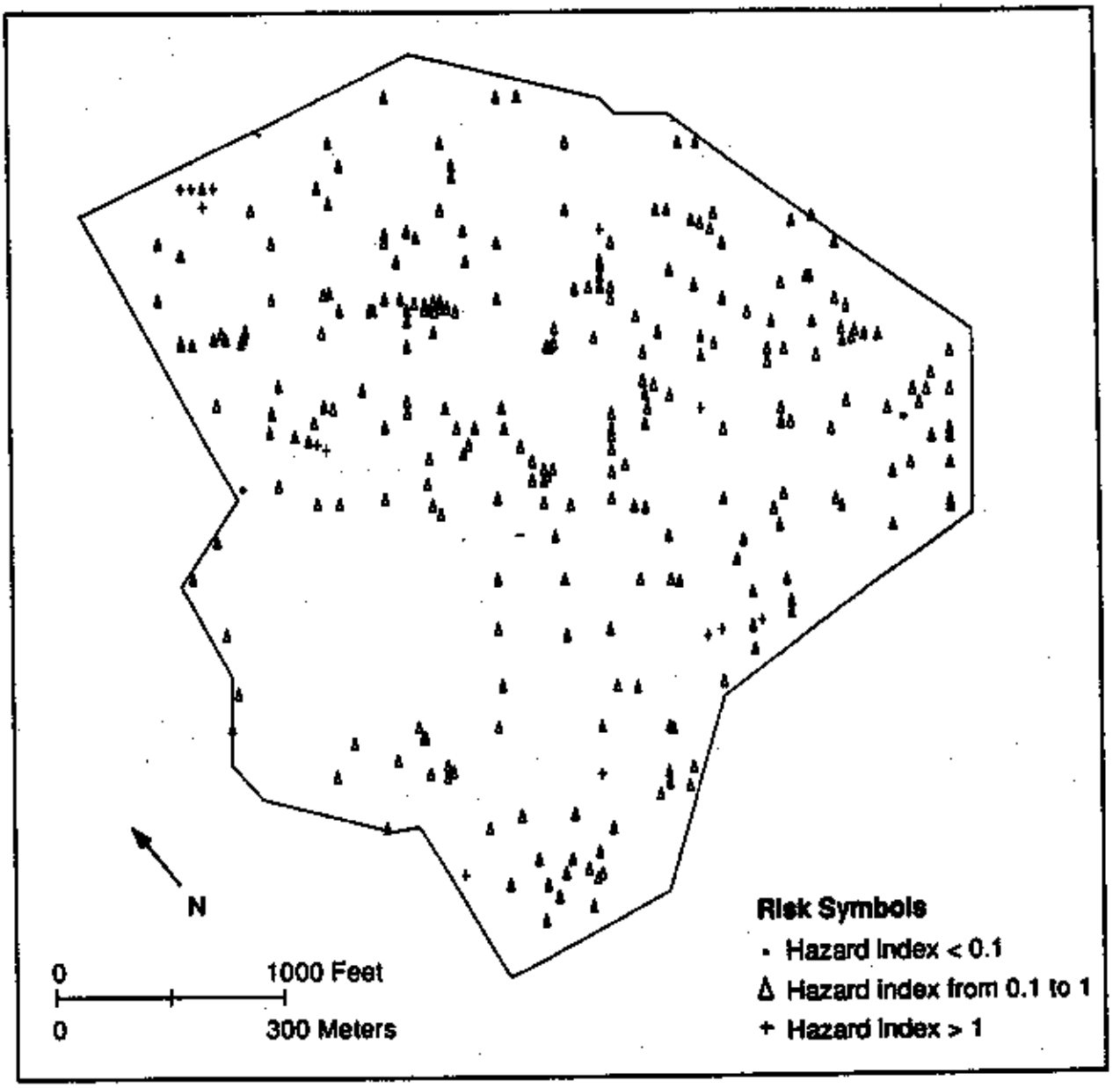

FIGURE E.5 Location-Specific Hazard Indexes for the Hypothetical Resident

TABLE E.1 Basis of Exposure Point Concentrations for the Exposure Pathways[a]

Exposure Pathway	Basis of Exposure Point Concentration			
	Recreational Visitor	Ranger	Resident	Farmer
External gamma irradiation[b]				
Indoor	-	Location-specific	Location-specific	Ash Pond UL_{95}
Outdoor	Sitewide UL_{95}	Sitewide UL_{95}	Location-specific	Ash Pond UL_{95}
Inhalation of radon[c]				
Indoor	-	Location-specific	Location-specific	Ash Pond UL_{95}
Outdoor	Sitewide UL_{95}	Sitewide UL_{95}	Location-specific	Ash Pond UL_{95}
Inhalation of particulates				
Indoor	-	Location-specific	Location-specific	Ash Pond UL_{95}
Outdoor	Sitewide UL_{95}	Sitewide UL_{95}	Location-specific	Ash Pond UL_{95}
Incidental ingestion of soil/dust	Sitewide UL_{95}	Sitewide UL_{95}	Location-specific	Ash Pond UL_{95}
Ingestion of food and drink				
Fish[d]	Average	Average	Average	Average
Game[e]	Sitewide UL_{95}	Sitewide UL_{95}	Sitewide UL_{95}	Sitewide UL_{95}
Fruits and vegetables[e]	-	-	-	Ash Pond UL_{95}
Beef and dairy products[e]	-	-	-	Ash Pond UL_{95}
Drinking water[f]	-	-	Location-specific	[g]

[a] This table presents information discussed in Sections E.4.1.1 and E.4.1.3. Except for footnote g, a hyphen indicates that the pathway does not apply to the scenario. Except as noted in footnotes b through f, the following apply: *Location-specific* means that the assessment was performed for each sampling location on the basis of surficial contaminant concentrations specific to that location (see text); *Sitewide* UL_{95} means that the 95% upper confidence limit of the arithmetic average for surface measurements across the site was used as the exposure point concentration for each contaminant; and *Ash Pond* UL_{95} means that the 95% upper confidence limit of the arithmetic average for surface measurements within the Ash Pond area was used as the exposure point concentration for each chemical. For radionuclides, the value was determined by kriging and contouring the uranium data for the Ash Pond area, and incorporating results of the radiological source term analysis; the weighted average estimated for the surface interval was then used as the exposure point concentration.

[b] The surface measurements of external gamma exposure rates (used to estimate the sitewide UL_{95}, location-specific, and Ash Pond UL_{95} values) include contributions from subsurface radionuclides.

[c] For outdoor exposures, the sitewide UL_{95} for surficial radium-226 was used to derive the exposure point concentration for radon-222 and its short-lived decay products. For indoor exposures, to address emanation through a basement or foundation slab, both surface and subsurface (3-m [10-ft]) measurements of radium-226 were used to derive the location-specific and Ash Pond UL_{95} exposure point concentrations.

[d] The average concentration determined for fish cakes and fillets from Lakes 34, 35, and 36 combined was used as the exposure point concentration for uranium (the contaminant of concern for this pathway).

[e] The basis shown is for the initial soil concentrations used to model the contaminant concentrations in game animals, fruits and vegetables, and beef and dairy products.

[f] Available groundwater data were contoured so that current concentrations could be estimated for groundwater beneath the boreholes addressed in the location-specific assessment of soil-related exposures. An analysis was also performed for the future scenario, predicting groundwater concentrations by estimating the contribution from leaching of soil contaminants on the basis of sitewide UL_{95} values.

[g] The farmer was represented by the resident for the preliminary analysis of drinking water ingestion (see text).

TABLE E.2 Exposure Scenario Assumptions and Intake Parameters[a]

Parameter	Variable	Unit[b]	Recreational Visitor	Ranger	Resident	Farmer
Average body weight	BW	kg	70	70	70 (15)[c]	70
Exposure time						
Indoor	ET	h/d	-	4	23	20
Outdoor	ET	h/d	4	4	1	4
Exposure frequency	EF	d/yr	20	250	350	350
Exposure duration	ED	yr	30	25	30	30
Inhalation rate						
Indoor	IR_a	m^3/h	-	1.0	0.8	0.8
Outdoor	IR_a	m^3/h	2.1	2.5	1.6	2.5
Filtration factor[d]	FF	-	-	0.8	0.8	0.8
Soil/dust ingestion rate[e]	IR_s	mg/d	120	120	100 (200)[f]	180
Food ingestion rate[g]						
Fruits	IR_f	g/d	-	-	-	42
Vegetables	IR_f	g/d	-	-	-	80
Beef	IR_f	g/d	-	-	-	75
Dairy products	IR_f	g/d	-	-	-	300
Drinking water ingestion rate	IR_w	L/d	-	-	2	-[h]
Shielding factor[i]	SF	-	-	0.7	0.7	0.7

[a] This table presents information discussed in Section E.4.1.2; except for footnote h, a hyphen indicates that the entry is not applicable.

[b] "Day" (d) is replaced by "event" for the recreational visitor.

[c] For incidental ingestion of soil and indoor dust, the average body weight is assumed to be 15 kg over a 6-year period and 70 kg over a 24-year period (see footnote f).

[d] This factor accounts for the reduction in indoor concentrations of airborne dust from outdoor soil as a result of the filtration effect of the structure.

[e] This rate represents the amount of contaminated soil and indoor dust assumed to be ingested per day.

[f] This receptor is assumed to incidentally ingest 200 mg/d for 6 years (15 kg average body weight) and 100 mg/d for 24 years (70 kg average body weight).

[g] For homegrown food; ingestion rates assumed for fish and game are presented in the BA (Table 3.4 and Sections 2.4.5.2 and 3.4.2.5).

[h] Represented by the resident for the preliminary analysis of this pathway (see text).

[i] This factor accounts for the reduction in indoor exposure to external gamma radiation compared with outdoor exposure as a result of attenuation by the structure.

TABLE E.3 Example Presentation of Radiological Data for Carcinogenic Effects from External Gamma Irradiation, Inhalation, and Incidental Ingestion for the Median Resident[a]

Exposure Route/ Contaminant[b]	Exposure Point Concentration[c]	Estimated Dose[d] (mrem)	Risk
External gamma irradiation	12	2,000	1×10^{-3}
Inhalation			
Actinium-227	3.8×10^{-6}	5.3	3×10^{-6}
Lead-210	2.8×10^{-5}	0.12	7×10^{-8}
Protactinium-231	7.5×10^{-6}	2.0	1×10^{-6}
Radium-226	2.8×10^{-5}	0.045	3×10^{-8}
Radium-228	1.5×10^{-5}	0.98	6×10^{-7}
Radon-222	4.6×10^{-3}	4.4	2×10^{-3}
Thorium-230	3.0×10^{-5}	2.0	1×10^{-6}
Thorium-232	1.5×10^{-5}	5.1	3×10^{-6}
Uranium-235	9.0×10^{-6}	0.24	1×10^{-7}
Uranium-238	2.0×10^{-4}	10	6×10^{-6}
Ingestion			
Actinium-227	0.15	2.3	1×10^{-6}
Lead-210	1.1	7.5	5×10^{-6}
Protactinium-231	0.30	3.3	2×10^{-6}
Radium-226	1.1	1.2	7×10^{-7}
Radium-228	0.60	1.2	7×10^{-7}
Thorium-230	1.2	0.65	4×10^{-7}
Thorium-232	0.60	1.7	1×10^{-6}
Uranium-235	0.36	0.092	6×10^{-8}
Uranium-238	7.9	4.1	2×10^{-6}
Total[e]			2×10^{-3}

[a] This table presents information discussed in Section E.4.1.3. The location at which the resident's radiological risk is the median value was selected for this presentation.

[b] Information for those contaminants for which no analysis was conducted was estimated from the radiological source term analysis (Table 2.3 of the BA).

[c] The unit for external gamma exposure is μR/h; the unit for inhalation exposure is pCi/m^3 in air, except for radon-222, for which the unit is working level (WL); and the unit for incidental ingestion exposure is pCi/g in soil. Incidental ingestion addresses both outdoor exposure to soil and indoor exposure to dust; the exposure point concentrations for dust were conservatively assumed to be the same as those for outdoor soil. Except for radon, the value listed for inhalation is for outdoor exposure; the value for indoor exposure can be calculated by multiplying the listed value by the filtration factor, 0.8. The value listed for radon-222 is for indoor exposure; indoor exposure accounts for more than 99% of the risk from radon inhalation for the resident.

[d] The committed effective dose equivalent was calculated from dose conversion factors given in Table 4.1 of the BA; the dose from radon-222 is in units of working-level month (WLM).

[e] The contributions from background concentrations of radon-222 and external gamma irradiation are included in this total; with background radon and external gamma irradiation excluded, the risk is 2×10^{-4}.

TABLE E.4 Example Presentation of Chemical Data for Carcinogenic Effects from Inhalation and Incidental Ingestion for the Median Resident[a]

Exposure Route/ Contaminant[b]	Exposure Point Concentration[c]	Average Daily Intake (mg/kg-d)	Risk
Inhalation			
Metals			
Arsenic	2.0×10^{-7}	1.9×10^{-8}	3×10^{-7}
Beryllium	6.3×10^{-9}	6.0×10^{-10}	5×10^{-9}
Cadmium	2.2×10^{-8}	2.1×10^{-9}	1×10^{-8}
Chromium VI	3.9×10^{-8}	3.8×10^{-9}	2×10^{-7}
Nickel	2.7×10^{-7}	2.6×10^{-8}	4×10^{-5}
PAHs[d]	-	-	-
Ingestion			
Metals			
Arsenic	7.8	1.2×10^{-5}	2×10^{-5}
Beryllium	0.25	3.9×10^{-7}	2×10^{-6}
PAHs[d]	-	-	-
PCBs	0.47	7.3×10^{-7}	6×10^{-6}
Nitroaromatic compounds	-	-	-
Total risk			3×10^{-5}

[a] This table presents information discussed in Section E.4.1.3. The location at which the resident's chemical risk is the median value was selected for this presentation; a hyphen indicates that the parameter was not detected in surface soil at the median location.

[b] Listed are only those exposure routes and contaminants for which an EPA slope factor is available. The EPA slope factors used to estimate the risks are given in Tables 4.4 and 4.5 of the BA.

[c] The unit for incidental ingestion exposure is mg/kg in soil; the unit for inhalation exposure is mg/m^3 in air. Incidental ingestion addresses both outdoor exposure to soil and indoor exposure to dust; the exposure point concentrations for dust were conservatively assumed to be the same as those for outdoor soil. For inhalation, the value listed is for outdoor exposure; the value for indoor exposure can be calculated by multiplying the listed value by the filtration factor, 0.8.

[d] The carcinogenic PAHs are benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and indeno(1,2,3-cd)pyrene.

TABLE E.5 Example Presentation of Chemical Data for Noncarcinogenic Effects from Inhalation and Incidental Ingestion for the Median Resident[a]

Exposure Route/ Contaminant[b]	Exposure Point Concentration[c]	Average Daily Intake (mg/kg-d)	Hazard Quotient
Inhalation			
Metals			
Barium	4.8×10^{-4}	1.1×10^{-6}	1×10^{-2}
Cadmium	6.3×10^{-9}	1.4×10^{-9}	7×10^{-6}
Chromium III	4.7×10^{-7}	1.1×10^{-7}	2×10^{-1}
Chromium VI	5.2×10^{-6}	1.2×10^{-6}	2×10^{-2}
Manganese	2.1×10^{-5}	4.7×10^{-6}	5×10^{-2}
Mercury	1.3×10^{-9}	2.8×10^{-10}	3×10^{-6}
Nitroaromatic compounds	-	-	-
Ingestion			
Metals			
Antimony	7.1	2.6×10^{-5}	6×10^{-2}
Arsenic	3.6	1.3×10^{-5}	4×10^{-2}
Barium	1.9×10^{2}	6.9×10^{-4}	1×10^{-2}
Beryllium	5.1×10^{-1}	1.9×10^{-6}	4×10^{-4}
Cadmium	2.5×10^{-1}	9.1×10^{-7}	9×10^{-4}
Chromium III	1.9×10^{1}	6.8×10^{-5}	7×10^{-5}
Chromium VI	2.1	7.6×10^{-6}	2×10^{-3}
Copper	9.3	3.4×10^{-5}	8×10^{-4}
Lithium	2.5	9.1×10^{-6}	5×10^{-4}
Manganese	8.4×10^{2}	3.1×10^{-7}	3×10^{-2}
Mercury	5.0×10^{-2}	1.8×10^{-7}	6×10^{-4}
Molybdenum	2.0	7.3×10^{-6}	2×10^{-3}
Nickel	3.0×10^{1}	1.1×10^{-4}	5×10^{-3}
Selenium	2.5×10^{-1}	9.1×10^{-7}	2×10^{-4}
Silver	5.0×10^{-1}	1.8×10^{-6}	4×10^{-4}
Thallium	5.0×10^{-1}	1.8×10^{-6}	3×10^{-2}
Uranium	7.7×10^{1}	2.8×10^{-4}	9×10^{-2}
Vanadium	3.5×10^{1}	1.3×10^{-4}	2×10^{-2}
Zinc	5.6×10^{1}	2.1×10^{-4}	1×10^{-3}
Inorganic anions			
Fluoride	1.7	6.2×10^{-6}	1×10^{-4}
Nitrate	8.4	3.0×10^{-5}	2×10^{-5}
Nitrite	2.5×10^{-1}	9.1×10^{-7}	9×10^{-6}
PAHs	-	-	-
PCBs	-	-	-
Nitroaromatic compounds	-	-	-
Total hazard index			0.6

See next page for footnotes

TABLE E.5 (Cont.)

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[a] This table presents information discussed in Section E.4.1.3. The location at which the resident's hazard index is the median value was selected for this presentation; a hyphen indicates that the parameter was not detected in surface soil at the median location.

[b] Listed are only those exposure routes and contaminants for which an EPA reference dose is available. The EPA reference doses used to estimate the hazard quotients are given in Tables 4.2 and 4.3 of the BA.

[c] The unit for incidental ingestion exposure is mg/kg in soil; the unit for inhalation exposure is mg/m^3 in air. Incidental ingestion addresses both outdoor exposure to soil and indoor exposure to dust; the exposure point concentrations for dust were assumed to be the same as those for outdoor soil. For inhalation, the value listed is for outdoor exposure; the value for indoor exposure can be calculated by multiplying the listed value by the filtration factor, 0.8.

TABLE E.6 Estimated Exposure Point Concentrations and Doses for the Farmer from Ingestion of Homegrown Food[a]

Contaminant	Ash Pond Soil Concentration[b] (pCi/g)	Estimated Concentration in Food (pCi/g)			Estimated Dose[c] (mrem)		
		Fruits and Vegetables	Beef	Dairy Products	Fruits and Vegetables	Beef	Dairy Products
Actinium-227	2.5	2.2×10^{-3}	7.5×10^{-4}	3.7×10^{-7}	4.2×10^{1}	8.8	1.8×10^{-2}
Lead-210	18	6.7×10^{-2}	3.1×10^{-4}	2.2×10^{-4}	5.8×10^{2}	1.6	4.7
Protactinium-231	4.9	3.1×10^{-3}	1.1×10^{-3}	5.3×10^{-7}	4.4×10^{1}	9.1	1.8×10^{-2}
Radium-226	18	5.5×10^{-2}	1.5×10^{-2}	7.4×10^{-4}	7.7×10^{1}	1.3×10^{1}	2.6
Radium-228	9.9	3.0×10^{-2}	8.1×10^{-3}	4.0×10^{-4}	7.6×10^{1}	1.3×10^{1}	2.5
Thorium-230	20	8.2×10^{-2}	2.8×10^{-2}	1.4×10^{-5}	5.6×10^{1}	1.2×10^{1}	2.3×10^{-2}
Thorium-232	9.9	4.2×10^{-2}	1.4×10^{-2}	7.1×10^{-6}	1.5×10^{2}	3.1×10^{1}	6.2×10^{-2}
Uranium-235	6.0	4.6×10^{-3}	1.6×10^{-3}	1.9×10^{-4}	1.5	3.1×10^{-1}	1.5×10^{-1}
Uranium-238	130	9.9×10^{-2}	3.4×10^{-2}	4.0×10^{-3}	6.5×10^{1}	1.4×10^{1}	6.5

[a] This table presents information discussed in Section E.4.1.3.

[b] The area-weighted averages from contoured surface measurements of uranium in the Ash Pond area, combined with information from the radiological source term analysis, were used to model the contaminant concentrations in food.

[c] The committed effective dose equivalent was calculated from dose conversion factors given in Table 4.1 of the BA.

TABLE E.7 Estimated Exposure Point Concentrations and Average Daily Intake of Chemicals for the Farmer from Ingestion of Homegrown Food[a]

Contaminant[b]	Ash Pond Soil Concentration[c] (mg/kg)	Estimated Concentration in Food (mg/kg)			Estimated Daily Intake Averaged over Exposure Period (mg/kg-d)		
		Fruits and Vegetables	Beef	Dairy Products	Fruits and Vegetables	Beef	Dairy Products
Metals							
Antimony	8.9	2.7×10^{-1}	1.5×10^{-3}	1.6×10^{-4}	4.5×10^{-4}	1.5×10^{-6}	6.4×10^{-7}
Arsenic	1.9×10^{1}	1.2×10^{-1}	8.3×10^{-4}	1.8×10^{-5}	1.9×10^{-4}	8.5×10^{-7}	7.6×10^{-8}
Barium	9.6×10^{2}	1.4×10^{1}	7.7×10^{-3}	2.7×10^{-2}	2.4×10^{-2}	7.9×10^{-6}	1.1×10^{-4}
Beryllium	9.0×10^{-1}	1.4×10^{-3}	7.4×10^{-6}	6.5×10^{-9}	2.3×10^{-6}	7.6×10^{-9}	2.7×10^{-11}
Cadmium	2.1	3.2×10^{-1}	3.0×10^{-4}	2.2×10^{-4}	5.4×10^{-4}	3.1×10^{-7}	9.1×10^{-9}
Chromium III	4.2×10^{1}	1.9×10^{-1}	2.0×10^{-3}	1.4×10^{-5}	3.2×10^{-4}	2.0×10^{-6}	5.8×10^{-8}
Chromium VI	4.7	2.1×10^{-2}	2.2×10^{-4}	1.6×10^{-6}	3.5×10^{-5}	2.3×10^{-7}	6.4×10^{-9}
Copper	3.9×10^{1}	9.8	4.9×10^{-1}	8.9×10^{-2}	1.6×10^{-2}	5.0×10^{-4}	3.6×10^{-4}
Lithium	8.8	3.5×10^{-2}	1.9×10^{-3}	3.9×10^{-3}	5.9×10^{-5}	2.0×10^{-6}	1.6×10^{-5}
Manganese	6.1×10^{2}	3.0×10^{1}	6.7×10^{-2}	5.3×10^{-2}	5.1×10^{-2}	6.9×10^{-8}	2.2×10^{-4}
Mercury	4.2×10^{-1}	8.3×10^{-2}	1.6×10^{-4}	4.9×10^{-6}	1.4×10^{-4}	1.6×10^{-7}	2.0×10^{-8}
Molybdenum	2.7×10^{1}	1.6	6.0×10^{-2}	1.2×10^{-2}	2.7×10^{-3}	6.1×10^{-6}	4.9×10^{-5}
Nickel	5.9×10^{1}	3.5	3.9×10^{-2}	5.1×10^{-4}	5.9×10^{-3}	4.0×10^{-5}	2.1×10^{-6}
Selenium	1.0×10^{1}	2.5×10^{-1}	2.1×10^{-2}	5.4×10^{-3}	4.3×10^{-4}	2.2×10^{-5}	2.2×10^{-5}
Silver	2.8	2.8×10^{-1}	3.0×10^{-3}	2.8×10^{-2}	4.6×10^{-4}	3.1×10^{-6}	1.1×10^{-4}
Thallium	3.4	1.3×10^{-3}	3.0×10^{-4}	1.4×10^{-5}	2.2×10^{-6}	3.0×10^{-7}	5.6×10^{-8}
Uranium	3.9×10^{2}	3.0	8.2×10^{-1}	9.4×10^{-2}	5.0×10^{-3}	8.4×10^{-4}	3.9×10^{-4}
Vanadium	3.7×10^{1}	1.1×10^{-1}	1.5×10^{-3}	1.2×10^{-5}	1.9×10^{-4}	1.6×10^{-6}	4.9×10^{-8}
Zinc	1.8×10^{2}	1.6×10^{2}	8.6×10^{1}	8.5	2.7×10^{-1}	8.8×10^{-2}	3.5×10^{-2}
Inorganic anions							
Fluoride	7.4	4.4×10^{-2}	3.7×10^{-2}	2.6×10^{-4}	7.4×10^{-5}	3.8×10^{-5}	1.1×10^{-6}
PAHs	-	-	-	-	-	-	-
PCBs	4.9×10^{-4}	3.6×10^{-6}	5.5×10^{-7}	1.7×10^{-7}	6.0×10^{-9}	5.6×10^{-10}	7.1×10^{-10}
Nitroaromatic compounds	-	-	-	-	-	-	-

TABLE E.7 (Cont.)

Contaminant[d]	Ash Pond Soil Concentration[c] (mg/kg)	Estimated Concentration in Food (mg/kg)			Estimated Daily Intake Averaged over Lifetime (mg/kg-d)		
		Fruits and Vegetables	Beef	Dairy Products	Fruits and Vegetables	Beef	Dairy Products
Metals							
Arsenic	1.9×10^{1}	1.2×10^{-1}	8.3×10^{-4}	1.8×10^{-5}	8.3×10^{-5}	3.6×10^{-7}	3.2×10^{-8}
Beryllium	9.0×10^{-1}	1.4×10^{-3}	7.4×10^{-6}	6.5×10^{-9}	9.7×10^{-7}	3.3×10^{-9}	1.2×10^{-11}
PAHs[e]	-	-	-	-	-	-	-
PCBs	4.9×10^{-4}	3.6×10^{-6}	5.5×10^{-7}	1.7×10^{-7}	2.9×10^{-10}	2.4×10^{-10}	3.0×10^{-10}
Nitroaromatic compounds	-	-	-	-	-	-	-

[a] This table presents information discussed in Section E.4.1.3. A hyphen indicates that the parameter was not detected in surface soil at the Ash Pond area.

[b] Listed are only those contaminants for which an EPA oral reference dose is available.

[c] The UL_{95} values for surface measurements in the Ash Pond area were used to model the contaminant concentrations in food, except for PCBs; for PCBs, an area-weighted average was used.

[d] Listed are only those contaminants for which an EPA oral slope factor is available.

[e] The carcinogenic PAHs are benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and indeno(1,2,3-cd)pyrene.

TABLE E-8 Estimated Milk Bioconcentration Factors[a]

Contaminant[b]	Milk Biotransfer Factor[c]	Source[d]
Radionuclides		
Actinium	2.5×10^{-6}	Napier et al. (1980)
Protactinium	2.5×10^{-6}	Napier et al. (1980)
Radium	2.0×10^{-4}	Napier et al. (1980)
Thorium	2.5×10^{-6}	Napier et al. (1980)
Uranium	6.0×10^{-4}	Napier et al. (1980)
Metals		
Antimony	1.1×10^{-4}	Ng et al. (1979)
Arsenic	3.0×10^{-5}	Stevens (1991)
Barium	3.5×10^{-4}	Ng et al. (1979)
Beryllium	9.1×10^{-7}	Ng et al. (1979)
Cadmium	1.3×10^{-4}	Stevens (1991)
Chromium	1.4×10^{-5}	Stevens (1991)
Cobalt	1.8×10^{-3}	Ng et al. (1979)
Copper	1.7×10^{-3}	Ng et al. (1979)
Lead	4.9×10^{-5}	Stevens (1991)
Lithium	2.0×10^{-2}	Baes et al. (1984)
Manganese	3.3×10^{-4}	Ng et al. (1979)
Mercury	1.1×10^{-5}	Stevens (1991)
Molybdenum	1.4×10^{-3}	Ng et al. (1979)
Nickel	2.7×10^{-5}	Stevens (1991)
Selenium	4.0×10^{-3}	Ng et al. (1979)
Silver	1.9×10^{-2}	Ng et al. (1979)
Thallium	1.9×10^{-3}	Ng et al. (1979)
Vanadium	2.0×10^{-5}	Ng et al. (1979)
Zinc	1.0×10^{-2}	Ng et al. (1979)
Inorganic anions		
Fluoride	1.1×10^{-3}	Ng et al. (1979)
PCBs[e]	8.7×10^{-3}	Mabey et al. (1982)

[a] This table presents information discussed in Section E.4.1.3.

[b] Listed are only those contaminants detected in surface soil at the Ash Pond area. Of the PCBs, only Aroclor 1254 was detected at one location.

[c] The milk biotransfer factor represents the fraction of the contaminant ingested daily with dietary plant tissue that is transferred to and remains in milk. The unit is d/L, except for lithium for which the unit is d/kg; the values in d/L can be converted to d/kg by dividing by 1.035 kg/L, which is the upper end of the range identified in Baes et al. (1984) for the density of milk.

[d] Values from Baes et al. (1984), Ng et al. (1979), and Stevens (1991) assume dry weight for plant tissue; values from Napier et al. (1980) assume wet weight for plant tissue. The value for PCBs was calculated from the octanol-water partition coefficient (K_{ow}) given in Mabey et al. (1982) with the following empirical relationship from Travis and Arms (1988) for estimating the bioconcentration factor (BCF) in milk, assuming dry weight for plant tissue:

$$\log BCF = -8.056 + 0.922 \log K_{ow}.$$

TABLE E.9 Estimated Pathway-Specific Radiological Risks[a]

Exposure Pathway	Radiological Risk					
	Recreational Visitor[b]	Ranger		Resident		Farmer[c]
		Range	Median	Range	Median	
External gamma irradiation	4×10^{-6}	4×10^{-5} - 6×10^{-4}	5×10^{-5}	0 - 6×10^{-3}	2×10^{-4}	3×10^{-5}
Inhalation[d]	5×10^{-5}	5×10^{-4} - 1×10^{-2}	5×10^{-4}	6×10^{-7} - 8×10^{-2}	2×10^{-5}	1×10^{-2}
Incidental ingestion of soil/dust	8×10^{-6}	NA[e]	9×10^{-5}	5×10^{-7} - 3×10^{-3}	1×10^{-5}	4×10^{-4}
Total	6×10^{-5}	6×10^{-4} - 1×10^{-2}	7×10^{-4}	1×10^{-6} - 9×10^{-2}	2×10^{-4}	1×10^{-2}

[a] This table presents information discussed in Section E.4.2.1. The estimated risks from external gamma irradiation and inhalation of radon decay products are the incremental risks above background; total risk (including background) is given for all other pathways.

[b] A range is not applicable for the recreational visitor because the risks for each pathway were estimated from sitewide exposures.

[c] A range is not applicable for the farmer because the risk for each pathway was estimated from exposures at a single area.

[d] The estimated risks include the contribution from contaminated airborne dust and the incremental contribution from radon-222 and its short-lived decay products.

[e] NA indicates that a range is not applicable for this receptor and pathway because the risk was evaluated from sitewide exposures, so it is represented by a single value (listed as median).

TABLE E.10 Estimated Contaminant-Specific Radiological Risks from External Gamma Irradiation, Inhalation, and Incidental Ingestion[a]

Exposure Route/ Contaminant	Radiological Risk[b]					
	Recreational Visitor	Ranger		Resident		Farmer
		Range	Median	Range	Median	
External gamma irradiation	4×10^{-6}	4×10^{-5} - 6×10^{-4}	5×10^{-5}	0 - 6×10^{-3}	2×10^{-4}	3×10^{-5}
Inhalation						
Actinium-227	6×10^{-7}	7×10^{-6} - 1×10^{-4}	8×10^{-6}	1×10^{-7} - 9×10^{-4}	3×10^{-6}	6×10^{-5}
Lead-210	2×10^{-8}	2×10^{-7} - 3×10^{-6}	2×10^{-7}	3×10^{-9} - 2×10^{-5}	7×10^{-8}	1×10^{-6}
Protactinium-231	2×10^{-7}	3×10^{-6} - 5×10^{-5}	3×10^{-6}	5×10^{-8} - 4×10^{-4}	1×10^{-6}	2×10^{-5}
Radium-226	7×10^{-9}	8×10^{-8} - 1×10^{-6}	8×10^{-8}	1×10^{-9} - 1×10^{-5}	3×10^{-8}	5×10^{-7}
Radium-228	1×10^{-7}	2×10^{-6} - 2×10^{-5}	2×10^{-6}	2×10^{-8} - 2×10^{-4}	8×10^{-7}	1×10^{-5}
Radon-222	4×10^{-5}	5×10^{-4} - 1×10^{-2}	5×10^{-4}	0 - 8×10^{-2}	1×10^{-5}	1×10^{-2}
Thorium-230	1×10^{-7}	2×10^{-6} - 4×10^{-5}	2×10^{-6}	5×10^{-8} - 3×10^{-4}	1×10^{-6}	2×10^{-5}
Thorium-232	7×10^{-7}	9×10^{-6} - 1×10^{-4}	9×10^{-6}	1×10^{-7} - 9×10^{-4}	3×10^{-6}	6×10^{-5}
Uranium-235	3×10^{-8}	3×10^{-7} - 8×10^{-6}	4×10^{-7}	5×10^{-9} - 4×10^{-5}	1×10^{-6}	3×10^{-6}
Uranium-238	1×10^{-6}	1×10^{-5} - 2×10^{-4}	2×10^{-5}	2×10^{-7} - 2×10^{-3}	5×10^{-6}	1×10^{-4}
Ingestion						
Actinium-227	8×10^{-7}	NA	7×10^{-6}	5×10^{-8} - 4×10^{-4}	1×10^{-6}	4×10^{-5}
Lead-210	3×10^{-6}	NA	3×10^{-5}	2×10^{-7} - 1×10^{-3}	4×10^{-6}	1×10^{-4}
Protactinium-231	1×10^{-6}	NA	1×10^{-5}	8×10^{-8} - 6×10^{-4}	2×10^{-6}	6×10^{-5}
Radium-226	5×10^{-7}	NA	5×10^{-6}	3×10^{-8} - 3×10^{-4}	8×10^{-7}	2×10^{-5}
Radium-228	5×10^{-7}	NA	5×10^{-6}	3×10^{-8} - 2×10^{-4}	1×10^{-6}	2×10^{-5}
Thorium-230	1×10^{-7}	NA	1×10^{-6}	1×10^{-8} - 1×10^{-4}	4×10^{-7}	1×10^{-5}
Thorium-232	7×10^{-7}	NA	7×10^{-6}	4×10^{-8} - 3×10^{-4}	9×10^{-7}	3×10^{-5}
Uranium-235	3×10^{-8}	NA	3×10^{-7}	2×10^{-9} - 2×10^{-5}	5×10^{-8}	2×10^{-6}
Uranium-238	1×10^{-6}	NA	1×10^{-5}	9×10^{-8} - 7×10^{-3}	2×10^{-6}	8×10^{-5}

[a] This table presents information discussed in Section E.4.2.1. The estimated risks from external gamma irradiation and inhalation of radon-222 decay products are the incremental risks above background; all other results include the contribution from background.

[b] A range is not applicable for the recreational visitor or the farmer because the risks for each pathway were estimated from sitewide exposures and single-area exposures, respectively. NA indicates that a range is not applicable because the ingestion risk was estimated from sitewide exposures for the ranger, so it is represented by a single value (listed as median).

TABLE E.11 Estimated Radiological Risks for the Farmer from Ingestion of Homegrown Food[a]

Contaminant	Radiological Risk		
	Fruits and Vegetables	Beef	Dairy Products
Actinium-227	3×10^{-5}	5×10^{-6}	1×10^{-8}
Lead-210	3×10^{-4}	1×10^{-6}	3×10^{-6}
Protactinium-231	3×10^{-5}	5×10^{-6}	1×10^{-8}
Radium-226	5×10^{-5}	8×10^{-4}	2×10^{-6}
Radium-228	5×10^{-5}	8×10^{-4}	2×10^{-6}
Thorium-230	3×10^{-5}	7×10^{-6}	1×10^{-8}
Thorium-232	9×10^{-5}	2×10^{-5}	4×10^{-9}
Uranium-235	9×10^{-7}	2×10^{-7}	9×10^{-8}
Uranium-238	4×10^{-5}	8×10^{-6}	4×10^{-6}
Total[b]	7×10^{-4}	6×10^{-5}	1×10^{-5}

[a] This table presents information discussed in Section E.4.2.1.

[b] For comparison, the risks estimated for ingestion of fruits and vegetables, beef, and dairy products at the off-site background location are 5×10^{-5}, 4×10^{-6}, and 5×10^{-7}, respectively.

TABLE E.12 Preliminary Estimates of Radiological Risks for the Resident from Ingestion of Drinking Water[a]

	On-Site Resident[b]			
	Current			Background Resident
Contaminant	Range	Median	Predicted	Predicted[c]
Actinium-227	-	-	1×10^{-5}	7×10^{-7}
Lead-210	-	-	3×10^{-4}	4×10^{-5}
Protactinium-231	-	-	5×10^{-5}	1×10^{-6}
Radium-226	-	-	5×10^{-5}	5×10^{-6}
Radium-228	-	-	5×10^{-5}	9×10^{-6}
Radon-222[d]	-	-	4×10^{-5}	4×10^{-6}
Thorium-230	-	-	1×10^{-6}	3×10^{-7}
Thorium-232	-	-	7×10^{-6}	1×10^{-6}
Uranium-235	4×10^{-8} - 2×10^{-6}	1×10^{-7}	1×10^{-6}	3×10^{-8}
Uranium-238	2×10^{-6} - 1×10^{-4}	5×10^{-6}	7×10^{-5}	1×10^{-6}

[a] This table presents information discussed in Section E.4.2.1. Predicted risks were calculated for an infiltration rate of 5 cm/yr (2 in./yr). Reductions in contaminant concentrations during transit to the aquifer, e.g., from radioactive decay, were not considered. The total risk for current conditions is represented by the estimates for uranium-238. No totals are presented for the predicted (future) conditions because breakthrough times would differ so the estimates in this table cannot be summed directly. This preliminary analysis will be expanded in documentation to be prepared for the groundwater operable unit after additional geological and hydrological data become available to better define potential migration.

[b] For current conditions, estimated for each location from contours of data available for groundwater beneath the site. Listed are the ranges and medians of the contaminant-specific values associated with borehole locations across the site; a hyphen indicates that the parameter has not been detected in site groundwater. For future conditions, potential risks were estimated from leaching calculations that used the sitewide UL_{95} values for soil.

[c] Estimated from leaching calculations that used the average radionuclide concentrations in local background soil.

[d] The estimated radiological risk associated with radon-222 in drinking water is largely due to inhalation of indoor air to which radon has volatilized. The radiological risk to the on-site resident under predicted future conditions from inhalation of radon volatilized from groundwater is 2×10^{-4}; the corresponding risk at the off-site background location is 2×10^{-5}. The risk from ingestion of radon-222 in drinking water was assumed to be 20% of that from inhalation (Mills 1990).

TABLE E.13 Estimated Pathway-Specific Chemical Carcinogenic Risks and Hazard Indexes[a]

Receptor	Inhalation		Incidental Ingestion		Total	
	Risk	Hazard Index[b]	Risk	Hazard Index[b]	Risk	Hazard Index[b]
Recreational visitor[c]	2×10^{-8}	0.008	2×10^{-6}	0.02	2×10^{-6}	0.02
Ranger						
Range	3×10^{-7} - 7×10^{-7}	0.1 - 0.3	NA[d]	NA	2×10^{-5}	0.3 - 0.5
Median	4×10^{-7}	0.2	2×10^{-5}	0.2	2×10^{-5}	0.4
Resident						
Range	4×10^{-8} - 3×10^{-6}	0.005 - 1	3×10^{-6} - 6×10^{-4}	0.08 - 9	3×10^{-6} - 6×10^{-4}	0.09 - 9
Median	6×10^{-7}	0.2	3×10^{-5}	0.3	3×10^{-5}	0.6
Farmer[e]	2×10^{-6}	0.9	5×10^{-5}	0.8	5×10^{-5}	2

[a] This table presents information discussed in Section E.4.2.2.

[b] The listed hazard indexes represent the totals for all critical effects, i.e., they have not been segregated according to the target organ and mechanism of action; for the farmer, the segregated hazard index is less than 1.

[c] A range is not applicable for the recreational visitor because the risks and hazard indexes for each pathway were estimated from sitewide exposures.

[d] NA indicates that a range is not applicable because incidental ingestion was evaluated from sitewide exposures for this receptor, so the risk and hazard index are represented by single values (listed as medians).

[e] A range is not applicable for the farmer because the risks and hazard indexes for each pathway were estimated from exposures at a single area.

TABLE E.14 Estimated Contaminant-Specific Chemical Carcinogenic Risks from Inhalation and Incidental Ingestion[a]

Exposure Route/ Contaminant[c]	Chemical Carcinogenic Risk[b]				
			Resident		
	Recreational Visitor	Ranger	Range	Median	Farmer
Inhalation					
Metals					
Arsenic	1×10^{-9}	5×10^{-7}	2×10^{-8} - 3×10^{-6}	2×10^{-7}	1×10^{-6}
Beryllium	5×10^{-10}	2×10^{-8}	5×10^{-9} - 1×10^{-7}	2×10^{-8}	3×10^{-8}
Cadmium	4×10^{-10}	2×10^{-8}	4×10^{-9} - 1×10^{-7}	4×10^{-9}	5×10^{-8}
Chromium VI	7×10^{-9}	2×10^{-7}	5×10^{-9} - 1×10^{-6}	2×10^{-7}	7×10^{-7}
Nickel	3×10^{-9}	4×10^{-8}	8×10^{-9} - 7×10^{-7}	7×10^{-9}	4×10^{-7}
PAHs[d]	3×10^{-10}	6×10^{-8}	1×10^{-8} - 5×10^{-7}	5×10^{-7}	-
Ingestion					
Metals					
Arsenic	8×10^{-7}	9×10^{-6}	1×10^{-6} - 2×10^{-4}	2×10^{-5}	4×10^{-5}
Beryllium	1×10^{-7}	1×10^{-6}	2×10^{-6} - 4×10^{-5}	5×10^{-6}	4×10^{-6}
PAHs[d]	3×10^{-7}	4×10^{-6}	1×10^{-5} - 6×10^{-4}	6×10^{-4}	-
PCBs[e]	6×10^{-7}	6×10^{-6}	3×10^{-6} - 2×10^{-4}	1×10^{-5}	7×10^{-6}
Nitroaromatic compounds					
2,4-DNT	3×10^{-10}	3×10^{-9}	NA	9×10^{-7}	-
2,6-DNT	6×10^{-10}	6×10^{-9}	NA	2×10^{-6}	-
TNT	2×10^{-11}	2×10^{-10}	NA	6×10^{-8}	-

[a] This table presents information discussed in Section E.4.2.2.

[b] A range is not applicable for the recreational visitor or the farmer because risks were estimated for each pathway from sitewide and single-area exposures, respectively. For the ranger, incidental ingestion was evaluated from sitewide exposures so risks are represented by a single value. For inhalation, the maximum value of the range is given because the values are low and the range is generally small. NA indicates that the range is not applicable because the parameter was found in surface soil at only one location, so the risk is represented by a single value (listed as the median); a hyphen indicates that the parameter has not been detected in surface soil at the Ash Pond area.

[c] Listed are only those exposure routes and contaminants for which an EPA slope factor is available.

[d] The carcinogenic PAHs are benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, and indeno(1,2,3-cd)pyrene. For the resident, the range and median of detected values are listed because these compounds were detected at only two locations (thus, the median and upper end of the range are the same), so the median and the lower end of the range would both be zero if all measurements were considered.

[e] For the resident, the range and median of detected values are listed because PCBs were detected at only a few locations, so the median and the lower end of the range would both be zero if all measurements were considered.

TABLE E.15 Estimated Contaminant-Specific Hazard Quotients from Inhalation and Incidental Ingestion[a]

Exposure Route/ Contaminant[c]	Hazard Quotient[b]				
			Resident[d]		
	Recreational Visitor	Ranger	Range	Median	Farmer
Inhalation					
Metals					
Barium	4×10^{-4}	4×10^{-2}	6×10^{-4} - 2×10^{-1}	9×10^{-3}	9×10^{-2}
Cadmium	8×10^{-7}	4×10^{-5}	7×10^{-6} - 2×10^{-4}	7×10^{-6}	1×10^{-4}
Chromium III	6×10^{-3}	2×10^{-1}	4×10^{-3} - 1	2×10^{-1}	6×10^{-1}
Chromium VI	7×10^{-4}	3×10^{-2}	5×10^{-4} - 1×10^{-1}	2×10^{-1}	7×10^{-2}
Manganese	1×10^{-3}	4×10^{-2}	4×10^{-5} - 2×10^{-1}	3×10^{-2}	6×10^{-2}
Mercury	2×10^{-7}	1×10^{-5}	3×10^{-6} - 6×10^{-5}	3×10^{-6}	4×10^{-5}
Nitroaromatic compounds					
NB	6×10^{-9}	2×10^{-6}	NA	1×10^{-5}	-
Ingestion					
Metals					
Antimony	1×10^{-3}	1×10^{-2}	3×10^{-2} - 4×10^{-2}	3×10^{-2}	6×10^{-2}
Arsenic	4×10^{-3}	5×10^{-2}	6×10^{-3} - 1	8×10^{-2}	2×10^{-1}
Barium	3×10^{-4}	4×10^{-3}	5×10^{-4} - 2×10^{-1}	9×10^{-3}	3×10^{-2}
Beryllium	1×10^{-5}	2×10^{-4}	2×10^{-4} - 4×10^{-3}	5×10^{-4}	4×10^{-4}
Cadmium	9×10^{-5}	1×10^{-3}	9×10^{-4} - 2×10^{-2}	9×10^{-4}	5×10^{-3}
Chromium III	2×10^{-6}	3×10^{-5}	2×10^{-6} - 4×10^{-4}	7×10^{-5}	1×10^{-4}
Chromium VI	5×10^{-5}	6×10^{-4}	4×10^{-5} - 9×10^{-3}	2×10^{-3}	2×10^{-3}
Copper	4×10^{-5}	5×10^{-4}	1×10^{-4} - 9×10^{-3}	1×10^{-3}	2×10^{-3}
Lithium	4×10^{-5}	5×10^{-4}	5×10^{-4} - 1×10^{-2}	1×10^{-3}	1×10^{-3}
Manganese	6×10^{-4}	8×10^{-3}	3×10^{-5} - 1×10^{-1}	2×10^{-2}	2×10^{-2}
Mercury	3×10^{-5}	4×10^{-4}	6×10^{-4} - 1×10^{-2}	6×10^{-4}	3×10^{-3}
Molybdenum	4×10^{-4}	6×10^{-3}	2×10^{-3} - 3×10^{-2}	2×10^{-2}	2×10^{-2}
Nickel	1×10^{-4}	1×10^{-3}	4×10^{-4} - 3×10^{-2}	3×10^{-3}	7×10^{-3}
Selenium	5×10^{-5}	7×10^{-4}	2×10^{-4} - 2×10^{-2}	2×10^{-4}	5×10^{-3}
Silver	2×10^{-5}	3×10^{-4}	4×10^{-4} - 1×10^{-2}	4×10^{-4}	1×10^{-3}
Thallium	1×10^{-3}	2×10^{-2}	3×10^{-2} - 6×10^{-1}	3×10^{-2}	1×10^{-1}
Uranium	6×10^{-3}	8×10^{-2}	1×10^{-3} - 8	2×10^{-2}	3×10^{-1}
Vanadium	5×10^{-4}	6×10^{-3}	1×10^{-3} - 4×10^{-2}	2×10^{-2}	1×10^{-2}
Zinc	3×10^{-5}	4×10^{-4}	2×10^{-5} - 9×10^{-3}	7×10^{-4}	2×10^{-3}
Inorganic anions					
Fluoride	9×10^{-6}	1×10^{-4}	4×10^{-5} - 1×10^{-3}	3×10^{-4}	3×10^{-4}
Nitrate	4×10^{-7}	3×10^{-5}	6×10^{-7} - 7×10^{-3}	4×10^{-6}	9×10^{-6}
Nitrite	4×10^{-7}	4×10^{-6}	9×10^{-6} - 2×10^{-4}	9×10^{-6}	6×10^{-6}
PAHs					
Acenaphthene	7×10^{-8}	8×10^{-7}	NA	1×10^{-4}	-
Anthracene	2×10^{-8}	3×10^{-7}	NA	4×10^{-5}	-
Benz(a)anthracene	6×10^{-7}	7×10^{-6}	5×10^{-5} - 1×10^{-3}	1×10^{-3}	-
Benzo(b)fluoranthene	3×10^{-7}	4×10^{-6}	NA	6×10^{-4}	-
Benzo(k)fluoranthene	3×10^{-7}	3×10^{-6}	NA	5×10^{-4}	-

TABLE E.15 (Cont.)

Exposure Route/ Contaminant[c]	Hazard Quotient[b]				
	Recreational Visitor	Ranger	Resident[d]		Farmer
			Range	Median	
Ingestion (cont.)					
PAHs (cont.)					
Benzo(g,h,i)perylene	1×10^{-7}	2×10^{-6}	NA	3×10^{-4}	-
Benzo(a)pyrene	4×10^{-7}	4×10^{-6}	NA	6×10^{-4}	-
Chrysene	6×10^{-7}	7×10^{-6}	$5 \times 10^{-5} - 1 \times 10^{-3}$	1×10^{-3}	-
Fluoranthene	6×10^{-7}	7×10^{-6}	$5 \times 10^{-5} - 1 \times 10^{-3}$	1×10^{-3}	-
Fluorene	8×10^{-8}	1×10^{-6}	NA	1×10^{-4}	-
Indeno(1,2,3-cd)pyrene	2×10^{-7}	3×10^{-6}	NA	4×10^{-4}	-
2-Methylnaphthalene	3×10^{-6}	3×10^{-5}	$5 \times 10^{-5} - 4 \times 10^{-3}$	8×10^{-4}	-
Naphthalene	9×10^{-7}	1×10^{-5}	NA	2×10^{-3}	-
Phenanthrene	9×10^{-7}	1×10^{-5}	$5 \times 10^{-5} - 1 \times 10^{-3}$	4×10^{-4}	-
Pyrene	1×10^{-6}	2×10^{-5}	$4 \times 10^{-5} - 2 \times 10^{-3}$	8×10^{-5}	-
PCBs	2×10^{-3}	2×10^{-2}	$1 \times 10^{-3} - 4 \times 10^{-1}$	3×10^{-2}	2×10^{-2}
Nitroaromatic compounds					
DNB	5×10^{-5}	7×10^{-4}	$4 \times 10^{-2} - 1 \times 10^{-1}$	1×10^{-1}	-
2,4-DNT	5×10^{-6}	7×10^{-5}	NA	2×10^{-2}	-
2,6-DNT	5×10^{-7}	6×10^{-6}	NA	1×10^{-3}	-
NB	4×10^{-6}	5×10^{-5}	NA	1×10^{-2}	-
TNB	7×10^{-5}	8×10^{-4}	$5 \times 10^{-2} - 2 \times 10^{-1}$	2×10^{-1}	-
TNT	4×10^{-6}	4×10^{-5}	NA	1×10^{-2}	-

[a] This table presents information discussed in Section E.4.2.2.

[b] A range is not applicable for the recreational visitor or the farmer because hazard quotients were estimated from sitewide and single-area exposures, respectively. For the ranger, incidental ingestion was evaluated from sitewide exposures, so risks are represented by a single value. For inhalation, the maximum value of the range is given because the values are low and the range is generally small. NA indicates that the range is not applicable because the parameter was found in surface soil at only one location, so the hazard quotient is represented by a single value (listed as the median); a hyphen indicates that the parameter was not detected in surface soil at the Ash Pond area.

[c] Listed are only those exposure routes and contaminants for which an EPA reference dose is available.

[d] For the organic contaminants (PAHs, PCBs, and nitroaromatic compounds), the range and median of detected values are listed because these compounds were detected at only a few locations, so the lower end of the range and the median would both be zero if all measurements were considered. (For those compounds detected at only two locations, the median and the upper end of the range are the same.)

TABLE E.16 Estimated Blood Lead Levels in Children[a]

Site Area	Lead Concentration in Environmental Medium[b]			Estimated Lead Level in Blood[c] (µg/dL)	Population % with Blood Lead Level >10µg/dL
	Soil (mg/kg)	Air (µg/m³)	Groundwater (µg/L)		
East of Ash Pond	14,000[d]	0.36	29	130	100
East of Ash Pond	1,900	0.048	3.5	18	93
Ash Pond drainage	1,100	0.028	12	11	63
North of Ash Pond	750	0.019	3.5	7.8	23
Southeast of North Dump	450[d]	0.011	11	5.8	5.5
Between raffinate pits	260	0.0064	3.8	3.7	0.22
Unspecified[e]	240	0.0060	15	4.3	0.68

[a] This table presents information for the Lead5 model analysis discussed in Section E.4.2.2.

[b] The value for air was derived from the soil measurement, and the value for groundwater was estimated from contours of available data, except as noted (see text).

[c] Listed is the geometric mean for children 0-72 months.

[d] Represents the 3-m (10-ft) average at this location because lead was elevated in the subsurface rather than the surface.

[e] Unspecified indicates that the listed value was not measured at any specific location; it represents the lead concentration recently proposed by the Missouri Department of Health (1992) for soil in residential settings. This value was assessed in combination with the average concentration of measurements from all groundwater monitoring wells at the site in which lead was detected.

TABLE E.17 Estimated Chemical Carcinogenic Risks for the Farmer from Ingestion of Homegrown Food[a]

Contaminant[b]	Chemical Carcinogenic Risk		
	Fruits and Vegetables	Beef	Dairy Products
Metals			
Arsenic	1×10^{-4}	7×10^{-7}	6×10^{-8}
Beryllium	1×10^{-5}	1×10^{-6}	5×10^{-11}
PAHs	-	-	-
PCBs	2×10^{-8}	2×10^{-9}	6×10^{-9}
Nitroaromatic compounds	-	-	-
Total[c]	2×10^{-4}	7×10^{-7}	6×10^{-8}

[a] This table presents information discussed in Section E.4.2.2. A hyphen indicates that the parameter has not been detected in surface soil at the Ash Pond area.

[b] Listed are only those contaminants for which an EPA oral slope factor is available.

[c] For comparison, the risks estimated for ingestion of fruits and vegetables, beef, and dairy products at the off-site background location are 1×10^{-4}, 5×10^{-7}, and 4×10^{-8}, respectively.

TABLE E.18 Estimated Hazard Quotients for the Farmer from Ingestion of Food[a]

Contaminant[b]	Hazard Quotient		
	Fruits and Vegetables	Beef	Dairy Products
Metals			
Antimony	1.1	3.8×10^{-3}	1.6×10^{-3}
Arsenic	6.4×10^{-1}	2.8×10^{-3}	2.5×10^{-4}
Barium	3.4×10^{-1}	1.1×10^{-4}	1.6×10^{-3}
Beryllium	4.5×10^{-4}	1.5×10^{-6}	5.4×10^{-9}
Cadmium	5.4×10^{-1}	3.1×10^{-4}	9.1×10^{-6}
Chromium III	3.2×10^{-4}	2.0×10^{-6}	5.8×10^{-8}
Chromium VI	7.0×10^{-3}	4.5×10^{-5}	1.3×10^{-6}
Copper	4.1×10^{-1}	1.2×10^{-2}	9.1×10^{-3}
Lithium	2.9×10^{-3}	1.0×10^{-4}	8.0×10^{-4}
Manganese	5.1×10^{-1}	6.9×10^{-4}	2.2×10^{-3}
Mercury	4.6×10^{-1}	5.5×10^{-4}	6.7×10^{-5}
Molybdenum	6.7×10^{-1}	1.5×10^{-2}	1.2×10^{-2}
Nickel	2.9×10^{-1}	2.0×10^{-3}	1.0×10^{-4}
Selenium	8.5×10^{-2}	4.3×10^{-3}	4.5×10^{-3}
Silver	9.2×10^{-2}	6.2×10^{-4}	2.3×10^{-2}
Thallium	3.2×10^{-2}	4.3×10^{-3}	8.0×10^{-4}
Uranium	1.7	2.8×10^{-1}	1.3×10^{-1}
Vanadium	2.7×10^{-2}	2.3×10^{-4}	7.0×10^{-6}
Zinc	1.3	4.4×10^{-1}	1.7×10^{-1}
Inorganic anions			
Fluoride	1.2×10^{-3}	6.3×10^{-4}	1.8×10^{-5}
PAHs	-[c]	-	-
PCBs	6.0×10^{-5}	5.6×10^{-6}	7.1×10^{-6}
Nitroaromatic compounds	-	-	-
Hazard index[c]	8	0.8	0.4

[a] This table presents information discussed in Section E.4.2.2. A hyphen indicates that the parameter has not been detected in surface soil at the Ash Pond area.

[b] Listed are only those contaminants for which an EPA oral reference dose is available.

[c] For comparison, the hazard indexes estimated for ingestion of fruits and vegetables, beef, and dairy products at the off-site background location are 3, 0.2, and 0.08, respectively.

TABLE E.19 Preliminary Chemical Carcinogenic Risks for the Resident from Ingestion of Drinking Water[a]

	On-Site Resident[c]			
	Current			Background Resident
Contaminant[b]	Range	Median	Predicted	Predicted[d]
Metals				
Arsenic	$<2 \times 10^{-4}$ - 4×10^{-4}	$<2 \times 10^{-4}$	1×10^{-3}	1×10^{-3}
Beryllium	-	-	3×10^{-5}	4×10^{-5}
PAHs	-	-	NP	NA
PCBs	-	-	NP	NA
Nitroaromatic compounds	-			
2,4-DNT	$<4 \times 10^{-6}$ - 2×10^{-4}	$<4 \times 10^{-6}$	NP	NA
2,6-DNT	$<9 \times 10^{-6}$ - 1×10^{-3}	$<9 \times 10^{-6}$	NP	NA
TNT	2×10^{-7} - 6×10^{-5}	3×10^{-6}	NP	NA

[a] This table presents information discussed in Section E.4.2.2. Predicted risks were calculated for an infiltration rate of 5 cm/yr (2 in./yr). Possible reductions in contaminant concentrations during transit to the aquifer for future conditions, e.g., from the biodegradation of nitroaromatic compounds, were not considered. No totals are presented because limited data are available to define current conditions and, for predicted (future) conditions, breakthrough times would differ so the estimates in this table cannot be summed directly. This preliminary analysis will be expanded in documentation to be prepared for the groundwater operable unit after additional geological and hydrological data become available to better define potential migration.

[b] Listed are only those contaminants for which an EPA oral slope factor is available.

[c] For current conditions, estimated for each location from contours of data available for groundwater beneath the site. Listed are the ranges and medians of the contaminant-specific values associated with borehole locations across the site; a hyphen indicates that the parameter has not been detected in site groundwater. The range and median values listed for the individual contaminants do not sum to a total risk because the lowest and highest concentrations for each contaminant are not present together at the same location. For future conditions, potential risks were estimated from leaching calculations that used the sitewide UL_{95} values for soil. NP indicates that a sitewide estimate was not predicted with leaching calculations because the contaminant was detected in soil at only a few locations, for which a location-specific analysis was conducted (see text).

[d] Estimated from leaching calculations that used UL_{95} values for soil at the off-site background location. NA indicates that the entry is not applicable because organic contaminants are not present at the background location.

TABLE E.20 Preliminary Hazard Quotients for the Resident from Ingestion of Drinking Water[a]

	On-Site Resident[c]			
	Current			Background Resident
Contaminant[b]	Range	Median	Predicted	Predicted[d]
Metals				
Antimony	<4-6	<4	1×10^{-1}	7×10^{-2}
Arsenic	$<9 \times 10^{-1}$ - 2	$<9 \times 10^{-1}$	6	6
Barium	$<8 \times 10^{-2}$ - 4×10^{-1}	8×10^{-2}	9×10^{-2}	1×10^{-1}
Beryllium	NQ	NQ	3×10^{-3}	5×10^{-3}
Cadmium	NQ	NQ	2×10^{-1}	7×10^{-2}
Chromium III	3×10^{-2} - 3×10^{-1}	2×10^{-1}	1×10^{-5}	1×10^{-5}
Chromium VI	NQ	NQ	2×10^{-2}	2×10^{-2}
Copper	NQ	NQ	4×10^{-3}	4×10^{-3}
Lithium	NQ	NQ	6×10^{-2}	9×10^{-2}
Manganese	7×10^{-3} - 2×10^{-1}	2×10^{-2}	7×10^{-2}	7×10^{-2}
Mercury	<2 10^{-1} - 1	$<2 \times 10^{-2}$	5×10^{-3}	3×10^{-3}
Molybdenum	$<3 \times 10^{-1}$ - 6	$<3 \times 10^{-1}$	2×10^{-1}	2×10^{-1}
Nickel	$<5 \times 10^{-2}$ - 5×10^{-1}	$<5 \times 10^{-2}$	1×10^{-2}	2×10^{-2}
Selenium	NQ	NQ	7×10^{-3}	3×10^{-2}
Silver	NQ	NQ	3×10^{-3}	1×10^{-3}
Thallium	<2 - 2×10^{1}	4	2×10^{-1}	1
Uranium	$<1 \times 10^{-1}$ - 4×10^{1}	$<1 \times 10^{-1}$	3×10^{-1}	5×10^{-3}
Vanadium	NQ	NQ	1×10^{-1}	2×10^{-1}
Zinc	NQ	NQ	8×10^{-4}	6×10^{-3}
Inorganic anions				
Fluoride	$<1 \times 10^{-1}$ - 1	$<1 \times 10^{-1}$	1×10^{-2}	1×10^{-2}
Nitrate	$<4 \times 10^{-3}$ - 2×10^{2}	1×10^{1}	8×10^{-3}	3×10^{-2}
Nitrite	NQ	NQ	NQ	NQ
PAHs	-	-	NP	NA
PCBs	-	-	NP	NA
Nitroaromatic compounds				
DNB	$<1 \times 10^{-1}$ - 6×10^{-1}	$<1 \times 10^{-1}$	NP	NA
2,4-DNT	$<6 \times 10^{-2}$ - 1	$<6 \times 10^{-2}$	NP	NA
2,6-DNT	$<1 \times 10^{-1}$ - 5×10^{-1}	$<1 \times 10^{-1}$	NP	NA
NB	$<3 \times 10^{-2}$ - 1×10^{-1}	$<3 \times 10^{-2}$	NP	NA
TNB	$<3 \times 10^{-1}$ - 9	$<3 \times 10^{-1}$	NP	NA
TNT	$<5 \times 10^{-2}$ - 4	$<5 \times 10^{-2}$	NP	NA

TABLE E.20 (Cont.)

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[a] This table presents information discussed in Section E.4.2.2. Predicted risks were calculated for an infiltration rate of 5 cm/yr (2 in./yr). Possible reductions in contaminant concentrations during transit to the aquifer for future conditions, e.g., from biodegradation of the nitroaromatic compounds, were not considered. No hazard index is presented because limited data are available to define current conditions and, for predicted (future) conditions, breakthrough times would differ so the hazard quotients in this table cannot be summed directly. This preliminary analysis will be expanded in documentation to be prepared for the groundwater operable unit after additional geological and hydrological data become available to better define potential migration.

[b] Listed are only those contaminants for which an EPA oral reference dose is available.

[c] For current conditions, estimated for each location from contours of data available for groundwater beneath the site. Listed are the ranges and medians of the contaminant-specific values associated with borehole locations across the site; a hyphen indicates that the parameter has not been detected in site groundwater. NQ indicates that the estimate was not quantified for that contaminant because either the detection frequency was low so contours could not be projected or the contaminant was not contoured because maximum concentrations resulted in very low hazard quotients. NP indicates that a sitewide estimate was not predicted with leaching calculations because the contaminant was detected at only a few locations (see text). For future conditions, hazard quotients were estimated from leaching calculations that used the sitewide UL_{95} values for soil. The range and median values listed for the individual contaminants do not sum to a hazard index because the lowest and highest concentrations for each contaminant are not present together at the same location.

[d] Estimated from leaching calculations with UL_{95} values for soil at the off-site background location. NA indicates that the entry is not applicable because organic contaminants are not present in soil at the background location.

TABLE E.21 Estimated Total Carcinogenic Risks and Hazard Indexes[a]

Receptor	Carcinogenic Risk[b]			Health Hazard Index for Noncarcinogenic Effects[c]
	Radiological	Chemical	Combined	
Recreational visitor	6×10^{-5}	2×10^{-6}	6×10^{-5}	0.02
Ranger[d]				
Range	6×10^{-4} - 1×10^{-2}	2×10^{-5}	6×10^{-4} - 1×10^{-2}	0.3 - 0.5
Median	7×10^{-4}	2×10^{-5}	8×10^{-4}	0.4
Resident				
Range	1×10^{-6} - 9×10^{-2}	3×10^{-6} - 6×10^{-4}	4×10^{-6} - 9×10^{-2}	0.09 - 9
Median	2×10^{-4}	3×10^{-5}	2×10^{-4}	0.6
Farmer[e]	1×10^{-2}	2×10^{-4}	1×10^{-2}	11

[a] This table presents information discussed in Section E.6.2. Potential contributions from drinking water ingestion are shown separately (Tables E.12, E.19, and E.20), and those from fish and game ingestion are discussed in Sections 2.4.5.2, 5.2.4, and 5.3.2 of the BA (DOE 1992a).

[b] Values shown represent total risks (i.e., including background) for all exposure pathways except radon inhalation and external gamma irradiation, for which incremental risks were calculated. The combined risk represents the approximated sum of radiological and chemical risks, considering the differences in borehole locations and estimation methods (see text).

[c] Represents the totals for all critical effects, i.e., the listed hazard indexes have not been segregated according to the target organ and mechanism of action; for the farmer at the Ash Pond area and for the resident at several locations, the segregated hazard index also exceeds 1.

[d] For chemical risks, because the variation is small and the results are rounded to one significant figure, the range and median are represented by the same value in this table.

[e] Results for the farmer include the contribution from ingesting homegrown food. The estimated radiological and chemical risks for this pathway are 7×10^{-4} and 2×10^{-4}, and the respective background risks are 5×10^{-5} and 1×10^{-4}. The estimated hazard indexes for on-site and off-site exposures are 9 and 3, respectively. The combined chemical risk for the farmer excluding the contribution from this pathway is 5×10^{-5} (Table E.13).

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APPENDIX F:

POTENTIAL HEALTH IMPACTS OF REMEDIAL ACTION

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Potential health impacts of remedial action at the Weldon Spring site were assessed by estimating the radiological and chemical risks to workers and the general public that could result from exposure to site releases. Such releases could occur during the excavation, treatment, transportation, and disposal activities associated with implementing any one of the four final action alternatives for site cleanup. Potential impacts for the final remedial action alternatives were evaluated in terms of the increased likelihood of cancer induction for both radioactive and chemical contaminants. Also evaluated were noncarcinogenic impacts for chemical contaminants and the potential for occupational injuries and fatalities.

The U.S. Environmental Protection Agency (EPA) has developed guidance for assessing risks associated with cleanup activities at a National Priorities List (NPL) site (EPA 1991b). The methodology in this guidance generally parallels that for assessing health impacts associated with baseline conditions at a site (EPA 1988b, 1989a). The scope of the assessment presented in this appendix is limited to impacts resulting from remedial action activities. Other components of the risk assessment process for the site are presented in the baseline assessment (BA) (U.S. Department of Energy [DOE] 1992a) and Appendix E of this document. The methodologies used for the exposure assessment, toxicity assessment, and risk characterization are described in detail in the BA; thus, the following discussion references the BA to limit redundancy.

From the analysis of preliminary alternatives in Chapter 4, four final remedial action alternatives were identified for detailed evaluation in this feasibility study (FS): Alternatives 6a, 7a, 7b, and 7c. Alternative 1, the no-action alternative, was also evaluated for the purpose of comparison with the action alternatives. The potential impacts to human health and the environment associated with Alternative 1 are given in the BA (DOE 1992a) and in the rebaseline assessment presented in Appendix E.

Alternative 6a consists of removing the contaminated material; chemically treating the sludge, soil, and sediment from the raffinate pits and the quarry (the quarry material would be in storage at the temporary storage area as a result of implementing a previous remedial action); and disposing of all contaminated material in an on-site cell. Alternative 7 consists of removing the contaminated material; vitrifying the sludge, sediment, and soil; and disposing of the contaminated material either on-site (7a) or off-site at the Envirocare facility near Clive, Utah (7b), or at the Hanford facility near Richland, Washington (7c). Potential health impacts resulting from on-site activities associated with implementing one of the four action alternatives are evaluated in Sections F.1 through F.6, and the risks from transporting the waste to an off-site facility (Alternatives 7b and 7c) are assessed in Section F.7. A summary comparison of potential health impacts for the action alternatives is presented in Section F.8.

F.1 CONTAMINANTS OF CONCERN

Both radioactive and chemical contaminants are present in waste residues and soil at the Weldon Spring site; the nature and extent of site contamination is presented in detail in the remedial investigation (RI) (DOE 1992b) and summarized in Section 1.3.3 of this FS. The contaminants of concern for the Weldon Spring site that were evaluated in the BA are presented in Table 1.2 of this FS. These contaminants were selected on the basis of historical data for site operations and an evaluation of the characterization data with respect to (1) the distribution and concentrations of contaminants in environmental media and (2) the potential contribution of contaminants to risks at the site. The contaminants considered in the BA were reviewed to determine if the list should be revised for this current assessment, i.e., to evaluate potential exposures associated with the remedial action period. All but two of the contaminants were retained for this assessment; radon-220 and asbestos were eliminated because the primary sources of elevated concentrations of these two contaminants — the chemical plant buildings — are scheduled to be dismantled as part of interim response actions for the site prior to the remedial action addressed in this FS (Section 1.5.1). Once the buildings have been dismantled and the resultant material placed in controlled storage, the exposures and risks associated with asbestos and indoor radon-220 and its decay products would no longer be relevant. Thus, in this assessment, the risks associated with exposure to all radionuclides in the uranium-238, uranium-235, and thorium-232 decay series that were included in the BA (except radon-220) were considered. For chemical contaminants, risks were assessed for metals, inorganic anions, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and nitroaromatic compounds.

F.2 EXPOSURE PATHWAYS

A complete exposure pathway consists of four components: (1) a source and mechanism of contaminant release to the environment (e.g., excavation of contaminated soil), (2) an environmental transport medium (e.g., air) for the released contaminants, (3) a point of human contact with the contaminated medium (referred to as the exposure point), and (4) a route of human exposure (e.g., inhalation) at the exposure point.

The primary sources of contamination at the site are the raffinate pits, Frog Pond, Ash Pond, South Dump, North Dump, coal storage area, temporary storage area (TSA), and material staging area (MSA) (Section 1.3.3). In addition to these source areas, soil at scattered locations on-site and at several locations off-site has been contaminated as a result of contaminant transport and/or past releases. The off-site locations include the Southeast Drainage; Burgermeister Spring and Lakes 34, 35, and 36 in the Busch Wildlife Area; and discrete soil vicinity properties (Figure 1.4). (Remedial action at the Southeast Drainage is not being addressed at this stage of the site cleanup process; it will be addressed in future environmental compliance documentation. Remedial action activities such as excavation and loading at these various areas could provide a mechanism for contaminant release. The principal contaminant release mechanisms and transport media associated with such activities are:

- Emission of radon-222 from radium-contaminated material to the atmosphere,

- Emission of gamma radiation from radioactively contaminated material to the atmosphere, and
- Emission of fugitive dust from radioactively and chemically contaminated material to the atmosphere.

Exposure can also occur through direct contact with radioactively and chemically contaminated material.

The primary sources of radon emissions and gamma radiation are the raffinate pits and the TSA. Although levels of radon gas and gamma radiation are elevated at certain other site locations (e.g., those with elevated radium contamination), levels at these areas would be much lower. For completeness, all on-site sources of radon gas and gamma radiation were included in this assessment. Fugitive dust would be generated during waste excavation, loading, treatment, unloading, and waste placement activities. Thus, the release of particulate emissions to the atmosphere was modeled for the remedial action period (Appendix C), and potential exposures from inhalation of fugitive dust for both on-site and off-site receptors were quantified (Sections F.5 and F.6). Emission of radon-222 during remedial activities was also modeled for off-site receptors; this modeling is summarized in Section F.4.1.2. Because fugitive dust could deposit on the ground at nearby off-site receptor locations, both incidental ingestion of soil and ingestion of homegrown produce from a garden were also assessed. Fugitive dust could also deposit on the face (e.g., lips) of on-site remedial action workers, so potential worker exposure from incidental ingestion of contaminated soil was assessed as well.

The fence surrounding the site and the presence of workers and guards preclude unauthorized entry by a member of the public for any significant amount of time; hence, direct contact by the public with contaminated material during the cleanup period is unlikely. Workers would wear protective clothing (coveralls, boots, and gloves) and respiratory protective equipment, as required, to minimize the likelihood for direct contact with contaminated material. Thus, the potential for dermal absorption of contaminants is expected to be low. Nevertheless, dermal exposures to contaminated soil were evaluated for this assessment. Health effects were quantified only for those contaminants for which dermal absorption fractions are available, in accordance with EPA recommendations (Schaum 1991). These values are available for only two of the contaminants of concern at the Weldon Spring site — cadmium and PCBs — so this assessment is limited. Because the results are insignificant relative to the other pathways quantified for the various receptors, they are not presented here. The uncertainty associated with estimating potential health effects for this pathway and the inability to quantify these effects for all contaminants is discussed in Section 5.5.2 of the BA (DOE 1992a).

On the basis of these considerations, the potential routes of human exposure to site contaminants presented in this assessment are:

- Inhalation of radon-222 and its short-lived decay products,
- External gamma irradiation,

- Inhalation of radioactively and chemically contaminated airborne dust,
- Incidental ingestion of radioactively and chemically contaminated soil, and
- Ingestion of garden produce grown on contaminated soil.

F.3 POTENTIAL RECEPTORS AND EXPOSURE SCENARIOS

F.3.1 General Public

The general public could potentially be exposed to radioactive and chemical contaminants from the site via airborne dust and gaseous emissions generated during the estimated 7 years that contaminated material would be handled (1993-1999). An area around the site that could potentially be impacted by site releases was identified on the basis of proximity to expected emission sources, the nature of those emissions, and the local meteorological conditions as they would affect atmospheric dispersion. Within this area, nine specific off-site receptor locations were selected for the analysis of potential risks to the general public. Potential receptors at these locations include nearby residents; students and a custodian at Francis Howell High School; children (ages 6 through 12) at a daycare facility in the former Weldon Spring Elementary School; and individuals working at the nearby highway maintenance facility, the Army Reserve Training Area, and the Busch Wildlife Area headquarters. These off-site receptors and the scenario descriptions are given in Table F.1*; the receptor locations are shown in Figure F.1.

The assumptions and intake parameters used to estimate the radiological and chemical exposures for each of the potential receptors are given in Table F.2. Off-site receptors could potentially be exposed through inhalation of airborne dust generated during remedial action activities, incidental ingestion of soil contaminated by particulates deposited on the ground, and — for the four nearby residential receptors — the ingestion of fruits and vegetables grown in home gardens. Although other potential receptors could be identified for the general public (e.g., individuals driving by the site on State Route 94 or visitors to the Weldon Spring Wildlife Area), risks to these receptors were not explicitly evaluated because their exposures would be less than those estimated for the specific receptors considered in this analysis.

In addition to assessing the potential health risks to these individual receptors, the potential health risks associated with exposures to radioactive contaminants were assessed for the population within a defined radius of the site. Two separate analyses were performed (Avci et al. 1992). In the first analysis, the estimated radiological risk was calculated for all persons living within an 80-km (50-mi) radius of the site. In the second analysis, the estimated risk was

*For readability, all tables in this appendix are presented in sequence at the end of the text of the appendix.

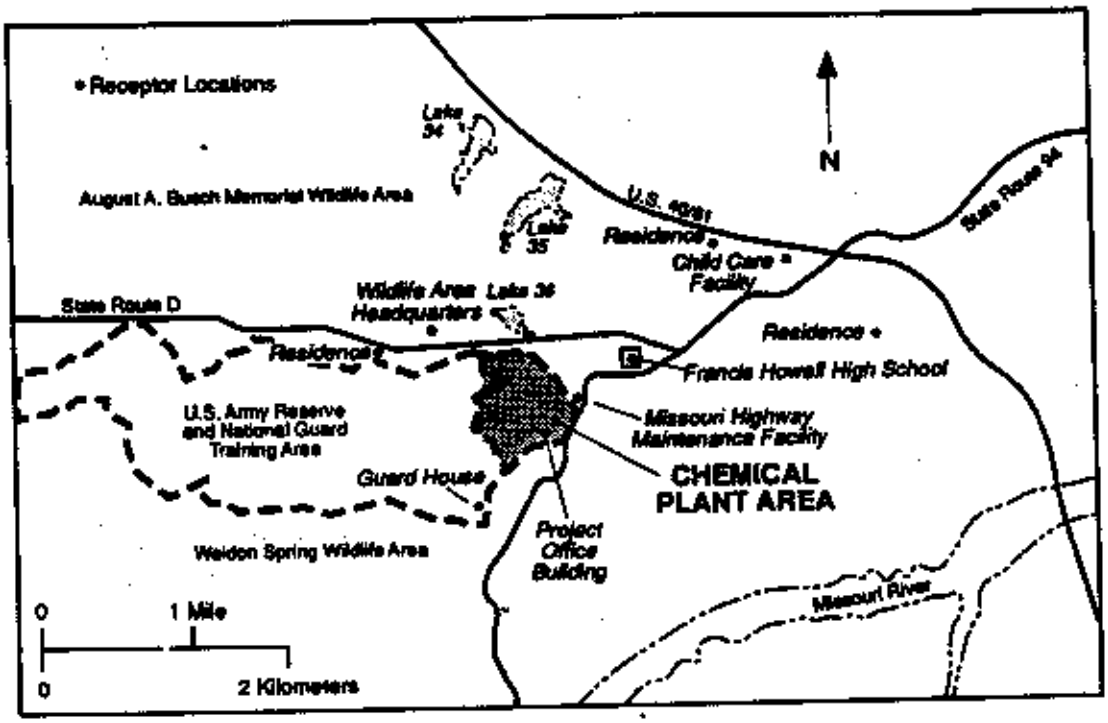

FIGURE F.1 Locations of Nearby Receptors

calculated for all individuals within a reasonable radius of impact, which was determined to be 5 km (3 mi) from the center of the site. This smaller radius corresponds to the distance at which the dose to a hypothetical individual is 5% of the maximum individual dose, which would occur to a hypothetical individual living at the site boundary (Avci et al. 1992). The results of these analyses indicate that no individual living in the vicinity of the site would receive a dose from the combined exposure pathways that could be associated with site activities in excess of 1 mrem/yr above background, which corresponds to the negligible individual risk level defined by the National Council on Radiation Protection and Measurements (NCRP 1987b).

A parallel assessment was not performed for chemical contaminants because the potential health risks to members of the general public were determined to be much lower than for the radioactive contaminants (see Sections F.5 and F.6). Thus, the potential health risks to members of the potentially impacted population are represented by those estimated for exposure to radioactive contaminants.

The probability of accidents involving the release of large quantities of contaminated material is low for several reasons, including (1) remedial action activities are largely limited to management of bulk solids (i.e., soil, sludge, and sediment), (2) the process vessels and tanks that would be managed during remedial action activities would be empty, (3) large quantities of explosive, flammable, or toxic chemicals (such as chlorine or acids) would not be brought to the site to support treatment activities (small quantities of these types of materials are currently in controlled storage on-site, awaiting disposal in a permitted facility), (4) treatment facilities would operate in a batch mode, processing relatively small quantities of material per batch, and

(5) an off-gas treatment system would be used for the vitrification facility to address its potential for significant airborne releases. Operations would be monitored to ensure that all systems were operating as required. If failures of specific components of the off-gas treatment system were to occur, activities would be shut down, and the components would be repaired and tested prior to restart. Thus, airborne releases resulting from accidents occurring on-site would be small compared with releases from routine remedial action activities. For example, a probable accident could involve a spill from a truck transporting material on-site; if all the truck contents were spilled, such an accident would involve about 15 m^3 (20 yd^3) of material, which is small compared with the volume of contaminated material that would be handled on a daily basis, i.e., about 380 to 760 m^3 [500 to 1,000 yd^3]. Therefore, exposures of the general public resulting from an on-site accident were not specifically assessed in this analysis. Assessment of the potential impacts associated with transportation of the waste off-site (including accidents) is presented in Section F.7.

F.3.2 Workers

Assessment of potential worker exposures included both on-site office workers and remedial action workers directly involved in handling contaminated material. The principal assumptions associated with estimating these exposures are given in Table F.2. The population risks to on-site office workers and remedial action workers were also assessed.

Remedial action workers and on-site office workers could be exposed to site contaminants while the various activities required to implement the selected alternative were being conducted. The potential exposure routes are external gamma irradiation, incidental ingestion of contaminated soil, inhalation of contaminated airborne particulates, and inhalation of radon-222 and its short-lived decay products. The main activities that would result in the generation of fugitive dust are soil excavation, treatment, loading/unloading, and surface grading. These activities would be conducted in accordance with health and safety plans developed for the Weldon Spring site in order to minimize potential occupational exposures to contaminants. Moreover, DOE is committed to keeping all exposures to workers as low as reasonably achievable (ALARA), as specified in DOE Order 5480.11 (see Appendix G, Table G.2). Workers at the site, working either with the contaminated material or in the vicinity of operations involving such material, would be supplied with protective clothing and equipment (such as respiratory protective equipment), as required. For this assessment, it was assumed that the workers would routinely wear appropriate protective clothing but would wear respiratory protective equipment only while handling the raffinate pit sludge and contaminated material at the TSA susceptible to becoming airborne.

Accidents that might occur during the various activities associated with the final action alternatives could result in short-term increases in worker exposures to contaminated material. Preventive measures and contingency plans would be in place for responding to potential accidents. Workers would utilize protective clothing and respiratory protective equipment, as necessary, and standard equipment and procedures would be used to clean up spills and conduct other activities required as the result of an accident. Because potential worker exposures resulting from an accident involving contaminated material would be similar to those occurring

during routine handling of such material, exposures associated with such an accident were not assessed in this analysis. However, impacts associated with occupational accidents (i.e., deaths or injuries) during implementation of the final remedial action alternatives were assessed (see Section F.6.3). These nonexposure-related impacts would be expected to occur during any construction project of equivalent size and scope.

F.4 EXPOSURE POINT CONCENTRATIONS

An exposure point concentration is the concentration of a specific contaminant in a given medium at the location of potential exposure. The exposure point concentrations of radioactive and chemical contaminants were estimated for each individual receptor location described in Section F.3. Because remedial action activities at the Weldon Spring site would involve the handling of material from a number of source areas at the site that are contaminated with varying concentrations of different contaminants, contaminant concentrations were developed for material at each area identified for excavation, treatment, and disposal. The concentrations of radioactive and chemical contaminants from various sources at the site are given in Tables F.3, F.4, F.5, and F.6; these data were used along with the model-predicted airborne and deposited particulate concentrations at nearby receptor locations (Appendix C, Section C.1.3.1) to estimate exposure point concentrations in the air and on the ground at these locations.

Exposure point concentrations were estimated separately for the on-site disposal alternatives, Alternatives 6a (chemical stabilization/solidification) and 7a (vitrification). Emissions of contaminated material from the site under Alternatives 7b and 7c (i.e., the off-site disposal alternatives) would generally be similar to or slightly less than those under Alternative 7a (Appendix C). Hence, the impacts in the vicinity of the Weldon Spring site for Alternatives 7b and 7c are represented by those for Alternative 7a. The differences in transportation impacts for these four alternatives are assessed in Section F.7. Exposure point concentrations of contaminants in air and soil for Alternatives 6a and 7a are discussed in Sections F.4.1 and F.4.2, respectively.

F.4.1 Air

F.4.1.1 Airborne Particulates

Airborne contaminant concentrations of chemicals and radionuclides other than radon-222 and its short-lived decay products were estimated for each off-site receptor location on the basis of atmospheric transport modeling and site-specific meteorological data (Appendix C, Table C.3). These concentrations were determined from the contaminant concentrations in the various media being remediated and the estimated air concentrations of respirable (i.e.,

PM-10*) particulates resulting from excavation, treatment, loading/unloading, and grading and compacting activities. The methodology used to estimate PM-10 particulate concentrations at the exposure points beyond the site perimeter and at the on-site office building is described in detail in Appendix C. Only the PM-10 estimates for fugitive dust originating from contaminated areas were used in this assessment; PM-10 estimates of dust generated by the movement of construction equipment on uncontaminated areas were not included. Engineering controls would be used during remedial action activities to minimize airborne releases (Appendix C). The estimated average airborne contaminant concentrations at each receptor location for the 7-year cleanup period are presented in Table F.7 for radionuclides and Tables F.8 and F.9 for chemicals. These contaminant concentrations were used to estimate potential inhalation exposures for the nearby receptors (A through I), which are presented in Section F.5.

The models used to estimate airborne particulate concentrations cannot be applied to an area close to a source, such as at the working face during excavation. Thus, the average concentration of total airborne particulates to which a remedial action worker (receptor K) would be exposed was assumed to be 5.0 mg/m^3, which is 33% of that allowed for worker exposure to nuisance particulates without requiring respiratory protection (see Appendix G, Table G.2). During remedial action activities, dust control measures would be implemented to control air particulate concentrations to this level, or respiratory protective equipment would be worn by the workers. The PM-10 particulate concentration was assumed to be one-fifth of the total airborne particulate concentration, i.e., 1.0 mg/m^3. This assumption is consistent with information provided in EPA (1989c). Because the worker would be involved in cleanup activities across the site, the airborne contaminant concentrations used to estimate inhalation exposures for this receptor were derived from UL_{95} (95% upper confidence limit of the arithmetic average) contaminant concentrations in sitewide soil.

Following the cleanup period, airborne releases are expected to be negligible. If the waste were disposed of on-site (Alternative 6a or 7a), the disposal cell would be routinely examined to ensure its integrity, and corrective actions would be performed as necessary. If the waste were disposed of off-site (Alternative 7b or 7c), on-site releases would be minimal because the sources of contamination would have been removed to another location where they would be contained. In either case, the site perimeter would be monitored following the cleanup period, as appropriate, to ensure that airborne emissions were kept well below applicable limits. Therefore, potential exposures associated with airborne emissions following the cleanup period have not been quantified in this assessment.

The CAP88-PC computer code (EPA 1992) was used for the radiological population dose assessment. This computer code is a collection of subprograms, databases, and associated utility programs developed by the EPA for assessing compliance of radionuclide releases with limits established under the Clean Air Act (see Appendix G, Table G.2). This code incorporates an environmental transport model that uses a modified Gaussian plume equation to estimate the average dispersion of contaminants released from a source area for a circular grid within a

*The term PM-10 refers to the respirable fraction of particulates, i.e., particulates with an aerodynamic diameter of ≤10 μm.

radius of 80 km (50 mi) around a facility. The airborne contaminant release rate from the site was modeled by combining the yearly release rates from individual source areas into a single composite source located at the center of the site. Release rates for individual source areas were obtained by multiplying the radionuclide concentration in each source area (Tables F.3 and F.4) by the corresponding emission rate for that source area (see Appendix C, Section C.3.4, for the emission rates for the various source areas). Release rates were modeled for each year of the 7-year cleanup period (see Avci et al. [1992] for additional information regarding the radiological population dose assessment).

F.4.1.2 Radon

In addition to radioactive particulate concentrations, the concentrations of radon-222 and its short-lived decay products were estimated at the various receptor locations. The releases of radon-222 from the site consist of two components: (1) releases from undisturbed material having elevated concentrations of radium-226 and (2) releases from the interstitial spaces in the contaminated material disturbed during remedial action activities. Releases of the first type were calculated from the estimated radon-222 flux (rate per unit area), exposed surface area, and length of time associated with remedial action activities; releases of this type are currently occurring at the site. Releases of the second type are directly related to remedial action activities. When contaminated material is excavated, radon gas that has accumulated in the interstitial spaces is released as the void spaces are exposed to the atmosphere. For this analysis, it was assumed that 20% of the total amount of radon-222 in the contaminated material could migrate out of the waste particulates into the surrounding void spaces and be released as the material was being excavated. In addition, it was assumed that the complete inventory of radon gas would be released from the material being vitrified under Alternative 7a. For assessment purposes, it was assumed that radon releases would occur at the center of the site. The total radon released from the site was estimated for each year of the 7-year cleanup period for Alternatives 6a and 7a. The annual average release rates are 35 and 50 Ci/yr for Alternatives 6a and 7a, respectively. The amount of radon released would be higher for Alternative 7a because of releases associated with the vitrification process.

The risk associated with radon-222 is due primarily to the inhalation of its short-lived decay products. Thus, the concentration of radon-222 alone is not a good measure of the hazard associated with this radionuclide. A more representative measure is the potential alpha energy associated with its short-lived decay products; the working level (WL) is such a unit of measure. One working level corresponds to 100 pCi/L of radon-222 in equilibrium with its short-lived decay products. One working level is defined as any combination of short-lived radon decay products in 1 liter of air, without regard to degree of equilibrium, that will result in the emission of 1.3×10^5 MeV of alpha energy.

Because the major hazard associated with radon-222 is its short-lived decay products, it is necessary to account for ingrowth of these decay products during atmospheric transport to the exposure points. The degree of ingrowth is given by the working-level ratio (WLR). The WLR is initially zero at the point of release and increases with time (and transit distance). The WLR has a value of one when the decay products have reached equilibrium with radon-222

The WLRs for the various exposure points were calculated with the algorithm incorporated in the CAP88-PC computer code. The estimated exposure point concentrations of radon-222 (in pCi/L) and its short-lived decay products (in WL) associated with remedial action activities at the Weldon Spring site are given in Table F.7.

The average concentration of radon-222 decay products to which remedial action workers would be exposed is estimated to be 0.001 WL (DOE 1987). This value is based on past experience at uranium milling facilities and on the radium-226 concentration in contaminated material at the Weldon Spring site. Although the concentration of radon-222 decay products would likely be higher when handling the raffinate pit sludge and contaminated material from the TSA, respiratory equipment would be used during these activities to minimize worker exposures. Therefore, this average value is used to estimate radon-222 exposures for remedial action activities at the site.

F.4.2 Soil

Radioactive and chemical contaminants could be deposited in the soil at the off-site receptor locations as a result of airborne particulates generated by the remedial action activities at the site. The amount deposited at each receptor location during the 7-year cleanup period was modeled, and it was assumed that contaminants in the soil at these locations would accumulate over the duration of the remedial action period; no mechanisms of contaminant removal, such as leaching or resuspension, were considered. The methodology and assumptions used to estimate the amount of deposited airborne particulates are given in Appendix C, Section C.1.3.1.

The exposure point concentrations of radioactive and chemical contaminants in soil at all receptor locations except receptor K were estimated from the contaminant concentrations in the various source areas and the amount of airborne particulates deposited on the ground. These soil concentrations were used to assess receptor exposures from ingestion of fruits and vegetables grown in contaminated soil, incidental ingestion of soil, and external gamma irradiation. Assessment of exposures associated with contaminated soil are discussed in Section F.5. The concentrations of radioactive contaminants in soil at each receptor location are given in Table F.10 for Alternatives 6a and 7a. Chemical concentrations in soil are given in Table F.11 for Alternative 6a and Table F.12 for Alternative 7a. For the on-site office worker and all off-site receptor locations, the soil concentrations represent the contaminant concentrations accumulated over the 7-year cleanup period.

The external gamma exposure rate to which remedial action workers would be exposed would be highly variable for the various site wastes. The exposure rate would be highest in the vicinity of the TSA and raffinate pit sludge and much lower in areas of contaminated soil. For example, the dose rate at the TSA was estimated to be 0.25 mrem/h for workers involved in the quarry bulk waste remedial action (DOE 1990), whereas the gamma dose rate from sitewide soil is estimated to be 0.012 mrem/h, including the background contribution of 0.0095 mrem/h. The latter values are based on the sitewide UL_{95} gamma exposure rate of 0.013 mR/h, a background exposure rate in the Weldon Spring area of 0.010 mR/h, and a dose conversion factor of 0.95 mrem/mR (DOE 1992a). Because shielding would be used as necessary and many of the

activities would not occur in proximity to the more highly contaminated material, an average dose rate of 0.05 mrem/h above background was used to estimate the doses to workers from exposure to external gamma radiation.

F.4.3 Comparison with Standards and Criteria

Previous EPA guidance for baseline risk assessments at NPL sites (EPA 1986) required a comparison of exposure point concentrations with applicable or relevant and appropriate requirements (ARARs). Although new guidance (EPA 1989a) no longer requires such a comparison, the exposure point concentrations given in Sections F.4.1 and F.4.2 were compared with potential ARARs to ensure compliance both with DOE guidelines for the protection of the general public and workers from airborne radioactive contaminants and with standards and guidelines for worker protection from the Occupational Safety and Health Administration (OSHA), the American Conference of Governmental Industrial Hygienists (ACGIH), and the National Institute for Occupational Safety and Health (NIOSH).

F.4.3.1 Radioactive Contaminants

For radioactive contaminants, demonstration of compliance with pertinent regulations and standards are generally based on dose, in mrem. Comparisons with applicable dose limits for both workers and members of the general public are discussed in Section F.5. However, derived concentration guides (DCGs) and derived air concentrations (DACs) for protection of members of the general public and workers, respectively, from airborne radioactive contaminants are provided in Table F.7 for purposes of comparison. The DCGs and DACs are established for planning purposes and as indicators that a potential exists for exposure to exceed the applicable dose limits. The DCGs and DACs relate to dose resulting from inhalation of individual radionuclides; therefore, to ensure compliance with a dose standard, the airborne concentrations must be reduced appropriately when two or more radionuclides are involved.

The DCGs are the concentrations that would result in an effective dose equivalent of 100 mrem under conditions of continuous inhalation exposure for 1 year. These values are based on an inhalation rate of 8,400 m^3 of air per year. The DCGs given in Table F.7 are taken from DOE Order 5400.5 (see Appendix G, Table G.2). The estimated airborne concentrations of individual radionuclides at all off-site receptor locations are considerably below the corresponding DCGs. The DACs are based on limiting either the committed effective dose equivalent to 5 rem/yr or the dose equivalent to any organ to 50 rem/yr, whichever is more restrictive. These values are based on an inhalation rate of 2,400 m^3 of air per year (i.e., 1.2 m^3/h during a 2,000-hour work year). The DACs given in Table F.7 are taken from DOE Order 5480.11 (see Appendix G, Table G.2). The estimated airborne concentrations of individual radionuclides at on-site receptor locations (receptors J and K) are considerably below the corresponding DACs.

F.4.3.2 Chemical Contaminants

Standards and guidelines that are available for occupational exposures to chemicals include the permissible exposure limits (PELs) of OSHA; the threshold limit values (TLVs) of the ACGIH; and the recommended exposure limits (RELs) of NIOSH. The PELs are promulgated standards and are pertinent to worker exposure during implementation of the selected remedial action alternative. In addition, DOE Order 5480.4 requires that worker exposures not exceed the TLVs established by the ACGIH. Site workers would not be exposed to airborne contaminant concentrations in excess of the more restrictive of these values. The estimated exposure point concentrations for Alternatives 6a and 7a are given in Tables F.8 and F.9; the PELs, RELs, and TLVs for airborne chemical contaminants are given in Table F.13. The estimated airborne concentrations at on-site receptor locations (receptors J and K) are considerably below the recommended occupational exposure limits.

F.5 ESTIMATED DOSES AND INTAKES OF CONTAMINANTS

Estimates of exposure are based on the contaminant concentrations at the exposure points (Section F.4) and scenario-specific assumptions and intake parameters. Scenario-specific assumptions include factors such as the age and weight of a potential receptor and the frequency and duration of exposure to contaminated media; intake factors are specific to the route of exposure, e.g., inhalation and ingestion rates. The assumptions used to estimate radiological and chemical exposures for the general public and workers are discussed in Section F.3 and summarized in Table F.2.

For radioactive contaminants, exposure is expressed in terms of (1) the 50-year committed effective dose equivalent for all exposure pathways except inhalation of radon-222 and its short-lived decay products and (2) the working-level month for inhalation of radon decay products (see Section 3.4.1 of the BA [DOE 1992a] for additional discussion of these concepts). For chemical contaminants, exposure is expressed in terms of intake, which is the amount of contaminant taken into the body per unit body weight per unit time. Exposures were estimated for the radioactive and chemical contaminants for each of the receptors identified in Section F.3 for both Alternative 6a and Alternative 7a.

F.5.1 General Public

F.5.1.1 Radioactive Contaminants

Radiological exposures were calculated for each individual receptor with pathway-specific equations and receptor-specific intake parameters (Table F.2). For each pathway, the exposure point concentration was multiplied by the quantity of the intake and the appropriate dose conversion factor, which gives the dose (in mrem) for a unit intake of a radionuclide. In addition to inhalation, airborne contaminants released during the cleanup period could deposit on the ground, resulting in three additional pathways of exposure — external gamma irradiation,

incidental ingestion of contaminated soil, and ingestion of homegrown produce. Although these three potential exposure pathways are not expected to be significant, the radiation doses associated with these pathways were evaluated for completeness.

The specific equations used to assess these exposure routes are the same as those given in the BA (DOE 1992a): inhalation of airborne particulates, Equation 3.15; inhalation of radon decay products, Equation 3.14; external gamma irradiation, Equation 3.9; incidental ingestion of soil, Equation 3.10; and ingestion of food, Equation 3.17. The dose conversion factors were the same as those used for the BA (see Sections 3.4.1 and 4.1 of the BA).

The results of these calculations indicate that, for all off-site receptors, the radiological exposures from ingestion of food and incidental ingestion of soil would be very low (about 1% of the total dose) compared with the other routes of exposure. In addition, exposure to external gamma irradiation from radioactive contaminants deposited on the ground would be insignificant (i.e., less than 0.1% of the total dose). Therefore, the radiological doses associated with these three exposure routes were not considered further in this assessment.

The estimated annual radiological doses from inhalation to individual members of the general public in the vicinity of the Weldon Spring site during the remedial action period are presented in Table F.14 for Alternatives 6a and 7a. These doses account for more than 98% of the total dose from all routes of exposure. The total dose to the hypothetical maximally exposed member of the general public from transportation activities for Alternatives 7b and 7c is estimated to be 0.11 mrem (Section F.7.3.1). The health risks associated with these radiological exposures are discussed in Sections F.6 and F.7. All doses to members of the general public are well below the limit of 100 mrem/yr specified in DOE Order 5400.5.

In addition to estimating doses to individual receptors, the off-site population doses from radioactive contaminants were calculated for all persons residing within an 80-km (50-mi) radius of the site (about 3 million persons). The CAP88-PC computer code was used to estimate population doses for exposures from inhalation, ingestion, and external gamma irradiation from air immersion and radionuclides deposited on the ground. From the results of these calculations, a radius of reasonable impact was inferred. The reasonable radius of impact was determined to be 5 km (3 mi) from the site center, within which about 10,700 persons are estimated to reside (Section F.3.1). (This estimate is based on 1990 census data and the average population density of St. Charles County. The number of people actually residing within this radius is significantly lower. Hence, the population doses calculated for the potentially impacted population are overestimated.) The estimated doses to the population residing within 5 and 80 km (3 and 50 mi) of the site over the entire remedial action period are 5.5 and 34 person-rem, respectively, for Alternative 6a and 4.6 and 32 person-rem, respectively, for Alternative 7a. The major source of this dose is inhalation of thorium-230 and radon-222 decay products. Details on the population dose assessment are given in the report of Avci et al. (1992). The population doses resulting from transportation activities are estimated to be 4.4 and 5.8 person-rem for Alternatives 7b and 7c, respectively (Section F.7.3.1).

F.5.1.2 Chemical Contaminants

Exposures to chemical contaminants in terms of intake were estimated for each individual receptor with route-specific equations and receptor-specific intake variables (Table F.2). In general, to estimate intake, the exposure point concentration is multiplied by appropriate intake variables and divided by the assumed body weight and either the number of days in the exposure period for noncarcinogenic effects or the number of days in a lifetime (70 years) for carcinogenic effects. The pathway-specific equations used to estimate intake are Equations 3.11, 3.16, and 3.18 from the BA (DOE 1992a) for incidental ingestion of soil, inhalation, and ingestion of homegrown produce, respectively. Because of the large number of chemical contaminants included in this assessment, the individual contaminant intakes for the various exposure pathways are not tabulated in this appendix. The results of the exposure assessment were used to calculate hazard indexes and chemical carcinogenic risks, which are presented in Section F.6.2.

F.5.2 Workers

During the remedial action period, on-site workers would include both remedial action workers directly involved with cleanup activities and project office workers. The total number of remedial action worker-years required for the final action alternatives is given in Table F.15; these values were used to estimate the collective impacts to workers for each alternative. The estimated remedial action worker requirements range from 560 to 1,100 person-years for Alternative 6a and Alternatives 7b and 7c, respectively. In addition, about 200 individuals would be working on-site in the project office building during this period. Assumptions for the exposure scenarios for a remedial action worker (receptor K) and an on-site office worker (receptor J) are given in Table F.2.

Workers involved in remedial action activities were assumed to be wearing protective clothing but generally not using any respiratory protective equipment, except when handling the raffinate pit sludge and contaminated material at the TSA susceptible to becoming airborne. This is a conservative assumption because respiratory protective equipment would probably be used for any activity having the potential for generating significant amounts of contaminated airborne releases. If respiratory protective equipment were used, the only significant exposure pathway for workers would be external gamma irradiation.

Cleanup activities are expected to occur during 7 years of the 10-year remedial action period. Because of the variety of activities involved, it is unlikely that any individual would work continuously on site cleanup activities for the entire 7 years. However, for this analysis, it was assumed that a worker would be exposed to site contaminants for 7 years. This calculation provides a conservative estimate of the health risk for any individual remedial action worker.

Following completion of remedial action activities, exposures of workers would be negligible because only monitoring and maintenance activities would be conducted and few workers would be involved. These activities would be similar for all of the alternatives because

it would be necessary to monitor the environment and perform maintenance activities at the disposal cell regardless of the location for waste disposal. Workers would be present periodically to collect air and water samples, to inspect and maintain the containment system, to maintain the fences and mow the grass, to patrol the site for security purposes, and to perform other routine monitoring and maintenance activities. During this time, workers would not be exposed directly to the wastes and all exposures would be negligible. However, if major repairs to the containment system were needed in the future, occupational doses could be significant. Such repairs could result in occupational exposures comparable to those estimated for implementing one of the four final remedial action alternatives over the same period.

F.5.2.1 Radioactive Contaminants

Radiological exposures to workers were generally calculated in the same manner as exposures to members of the public (Section F.5.1.1). The estimated annual doses to an on-site remedial action worker (receptor K) from exposure to radioactive contaminants are given in Table F.16; the annual dose to an on-site office worker (receptor J) is given in Table F.14.

The total dose to an on-site remedial action worker is estimated to be about 0.34 rem/yr from all pathways except inhalation of radon-222 decay products, which is estimated to be 0.025 WLM/yr. On the basis of the dose conversion factor of 1 rem/WLM given in Publication 32 of the International Commission on Radiological Protection (ICRP 1981), this radon-222 decay product exposure corresponds to a dose of 0.025 rem/yr. The dose from all exposure pathways is thus about 0.36 rem/yr, a value that is considerably below the occupational dose limit of 5 rem/yr given in DOE Order 5480.11. The collective radiological doses to remedial action workers for all activities except transportation are estimated to be 150 person-rem for Alternative 6a and 260 person-rem for Alternative 7a, 7b, or 7c (based on the worker projections given in Table F.15).

The occupational doses associated with transportation for Alternatives 7b and 7c are presented in Section F.7.3.1. These doses would be due exclusively to external gamma irradiation because the waste material would be packaged in containers prior to shipment. The maximum annual dose is conservatively estimated to be 0.1 rem/yr to a waste handler at the rail siding transfer station in Wentzville. The collective occupational dose for transportation is estimated to be 1.5 person-rem for either Alternative 7b or Alternative 7c (Section F.7.3.1). Therefore, the collective occupational doses for the four final remedial action alternatives are those estimated for remedial action workers, i.e., 150 person-rem for Alternative 6a and 260 person-rem for Alternative 7a, 7b, or 7c.

On-site office workers could be exposed to contaminated airborne dusts and radon-222 and its short-lived decay products. The collective dose to these workers for Alternative 6a is estimated to be 0.057 person-rem from inhalation of contaminated particulates and 0.25 person-WLM from inhalation of radon-222 decay products. The corresponding doses for Alternative 7a are 0.045 person-rem from inhalation of contaminated particulates and 0.38 person-WLM from inhalation of radon-222 decay products. For comparison, during the same period, these workers would receive a collective dose of about 280 person-WLM from

naturally occurring radon-222 decay products and a dose of about 140 person-rem from natural sources of radiation other than radon. The doses incurred by on-site office workers as a result of remedial action activities would be very low compared with those resulting from natural sources of radiation.

F.5.2.2 Chemical Contaminants

Chemical intakes for the office worker (receptor J) and the remedial action worker (receptor K) were estimated in the same manner as for members of the general public (Section F.5.1.2). Pathways considered for both receptors were inhalation of airborne contaminants generated during remedial activities and incidental ingestion of soil. The results of the exposure assessment were used to calculate hazard indexes and chemical carcinogenic risks, which are presented in Section F.6.2. Collective intakes and associated health risks for the entire work force are not presented for chemical contaminants because the risks associated with exposure to radioactive contaminants are much higher (see Section F.6). Thus, the potential health risks to the entire work force implementing one of the final remedial action alternatives are represented by the risks from exposure to radioactive contaminants.

F.6 HEALTH RISK EVALUATION

The potential health risks to the general public and workers from site cleanup activities were estimated for both radionuclides and chemicals; these risks are discussed in Sections F.6.1 and F.6.2, respectively. Potential risks were also estimated for nonexposure-related occupational accidents that could occur during remedial action, and these risks are discussed in Section F.6.3.

F.6.1 Radiological Risks

Radiological risks to the general public and workers were estimated on the basis of the doses given in Tables F.14 and F.16, respectively. The two primary concerns associated with exposures to low levels of ionizing radiation are cancer induction and serious genetic effects in future generations. The major health risk associated with the radionuclides at the Weldon Spring site is the induction of cancer. Hence, the assessment of radiological risks was limited to this concern, in accordance with EPA guidance (EPA 1989a). The likelihood of cancer induction was estimated on the basis of (1) the risk factor of 6×10^{-7}/mrem for all exposure pathways except inhalation of radon-222 and its short-lived decay products used by the EPA (1989b) and (2) a risk factor of 3.5×10^{-4}/WLM for inhalation of radon-222 decay products recommended in the BEIR IV study (National Research Council 1988). Because most lung cancers are fatal, this latter risk factor can also be used to estimate the rate of cancer induction. The estimated radiological risks to potential receptors in the vicinity of the Weldon Spring site are given in Table F.17.

The lifetime individual risks to the general public from radiation exposure as a result of remedial action activities would be very low, i.e., less than 1×10^{-6} for all receptors for all four final remedial action alternatives. For purposes of comparison, the dose from background

radiation is about 300 mrem/yr (NCRP 1987a). This dose corresponds to an annual risk of about 2×10^{-4}/yr for cancer induction or about 1×10^{-3} over the 7-year cleanup period. The radiological risks to the populations within 80 and 5 km of the site are conservatively estimated to be 2×10^{-2} and 3×10^{-3}, respectively, for either Alternative 6a or 7a. (The actual radius of impact is probably less than 5 km on the basis of the very low radiological risk estimated for off-site individuals within 3 km of the site.) It is unlikely that any cancer induction in off-site individuals would result from site releases during the remedial action period.

The radiological risks to members of the general public during waste transportation for Alternative 7b or 7c would also be low. The lifetime risk to a hypothetical maximally exposed member of the general public is estimated to be 7×10^{-8}, and the risk to the affected population is estimated to be 3×10^{-3} for Alternative 7b or Alternative 7c. It is highly unlikely that waste transportation would result in cancer induction for any member of the general public as a result of radiation exposure (see additional discussion in Section F.7.3). The health risks to members of the general public in the vicinity of the two alternative disposal sites (i.e., Envirocare or Hanford) would be extremely low on the basis of the distance to the nearest residences from the likely disposal cell location at these facilities.

The risks to workers are also expected to be low. The estimated risk to a remedial action worker who would be on-site for the entire 7-year cleanup period is estimated to be about 1×10^{-3}. The maximally exposed worker associated with off-site transportation of waste for Alternative 7b or 7c would be a waste handler at the Wentzville rail siding; the risk to this worker is estimated to be 2×10^{-4}. The collective risk to the entire work force is estimated to be 9×10^{-2} for Alternative 6a and 2×10^{-1} for Alternative 7a, 7b, or 7c. The risk to an office worker at the Weldon Spring site is estimated to be 6×10^{-7} for Alternative 6a and 8×10^{-7} for Alternative 7a, 7b, or 7c; the corresponding collective risks to all on-site office workers are estimated to be 1×10^{-4} and 2×10^{-4}, respectively. It is unlikely that the proposed action would result in adverse health effects to the project work force (i.e., remedial action workers and on-site office workers) from exposure to radioactive contaminants.

F.6.2 Chemical Risks

F.6.2.1 Carcinogenic Risks

The potential risk to an individual resulting from exposure to chemical carcinogens is expressed as the increased probability of a cancer occurring over the course of a lifetime. To calculate the excess cancer risk, the daily intake averaged over a lifetime is multiplied by a chemical-specific slope factor. Slope factors have been derived by EPA for a number of carcinogens to represent the lifetime cancer risk per milligram of carcinogen per kilogram of body weight, assuming that the exposure occurs over a lifetime of 70 years.

A slope factor is specific to the chemical and the route of exposure, e.g., inhalation or ingestion. The slope factors given in Tables 4.4 and 4.5 of the BA (DOE 1992a) were used for this assessment. The estimated risks to a remedial action worker, an on-site office worker, and

members of the general public from exposures to chemical contaminants are given in Tables F.18 and F.19 for Alternatives 6a and 7a, respectively. The potential health effects estimated for off-site receptors A through D from ingestion of homegrown produce are insignificant relative to parallel estimates for background exposures; therefore, they are not included in these tables. The total risks estimated for the nine general public receptors range from 6×10^{-10} to 3×10^{-8} for Alternative 6a and from 5×10^{-10} to 3×10^{-8} for Alternative 7a. Because these risks are very low, no adverse effects to the general public are expected to result from exposures to chemical carcinogens during remedial action activities.

The chemical carcinogenic risk estimated for the on-site office worker is 5×10^{-8} for Alternative 6a and 6×10^{-8} for Alternative 7a. The total carcinogenic risk for a remedial action worker from inhalation and incidental ingestion is estimated to be 8×10^{-5}. This value represents the risk from handling contaminated material each work day over the entire 7-year cleanup period. For this assessment, it was assumed that workers would wear respiratory protective equipment only when handling the raffinate pit sludge and contaminated material at the TSA susceptible to becoming airborne. -However, respiratory protective equipment would also be worn when there was an increased likelihood for generating significant amounts of airborne particulates, thus reducing potential exposure from both inhalation and ingestion. Wearing respiratory protective equipment would also prevent the incidental ingestion of soil. Thus, the actual risk to a remedial action worker would be lower than that given above. Although the unavailability of slope factors for all chemical carcinogens results in under-estimating the total carcinogenic risk, the estimated daily intakes of these compounds would result in very low doses, and the potential for carcinogenic effects from exposure to these contaminants would also be low.

F.6.2.2 Noncarcinogenic Risks

Potential adverse health effects resulting from exposures to noncarcinogens are assessed by comparing estimated intakes to EPA-established reference doses; a reference dose is the average daily dose that can be received without likely adverse health effects. Because cleanup activities at the Weldon Spring site are projected to occur over a 7-year period and the exposure duration assumed for all receptors except receptor E is 7 years, available chronic reference doses were used in this assessment to estimate potential noncarcinogenic health effects. The exposure duration assumed for the high school student (receptor E) was 4 years and, therefore, the use of subchronic reference doses would have been more appropriate for this receptor. However, chronic reference doses are the same or lower than subchronic reference doses, so the use of chronic reference doses results in potentially overestimating the likelihood for adverse health effects for receptor E and, thus, is more conservative.

Potential risks from exposure to a chemical are assessed by dividing the estimated intake by the EPA reference dose to derive a "hazard quotient" for the chemical. For an individual chemical, a hazard quotient of 1 or less is considered to indicate a nonhazardous situation or, conversely, a hazard quotient of greater than 1 is considered to indicate a potential for adverse health effects. The individual hazard quotients are then summed to determine an overall hazard index. Although chemical-specific hazard quotients may all be less than 1, their

sum may be greater than 1. In this case, the major toxicological effects and mechanisms of action of the individual chemicals are examined to determine the potential impact associated with exposure to multiple contaminants. The primary contributors to the total hazard index are grouped according to their health end points, and a separate hazard index is defined for each group; this is referred to as segregation of the hazard index.

Reference doses are not available for all contaminants for the routes of exposure considered in this analysis; the available reference doses are given in Tables 4.2 and 4.3 of the BA (DOE 1992a). The hazard indexes for the general public and worker scenarios are presented in Tables F.20 and F.21 for Alternatives 6a and 7a, respectively. Because a hazard quotient could not be calculated for all chemicals, the calculated hazard indexes underestimate the actual potential for adverse health effects. However, for the general public, these values are all less than 0.001, which is considerably below EPA's level of concern for noncarcinogenic effects (i.e., a hazard index of greater than 1). Although the lack of reference doses for some contaminants results in underestimating the potential for adverse health effects based on the overall hazard index, the estimated daily intakes of these contaminants would result in very low doses and the potential for adverse health effects from exposure to these contaminants is expected to be low.

The hazard index for the on-site office worker for either Alternative 6a or Alternative 7a is 0.001, which is well below the level of concern. The hazard index for the remedial action worker was 10 for the inhalation pathway and 3 for the ingestion pathway. Segregating the hazard index by health end point and mechanism of action still results in hazard indexes of greater than 1 for both exposure routes, indicating some potential for adverse health effects to this individual. (The method for segregating the hazard index is described in Section 5.1.2.2 of the BA [DOE 1992a].) The exposure assessment was based on the assumptions that this worker would be wearing protective clothing but, in general, no respiratory protective equipment and would be exposed to contaminated material during the entire 7-year cleanup period. However, in practice, workers would be provided with respiratory protective equipment during many of the remedial action activities (which would also prevent incidental ingestion of soil). Hence, a more realistic risk estimate for a worker would be significantly lower than the levels estimated for receptor K in this analysis.

F.6.3 Occupational Accidents

Occupational accidents could occur during the various activities associated with implementing any one of the final action alternatives. The estimated numbers of potential occupational fatalities and injuries are summarized in Table F.22; these impacts would be expected to occur during any construction project of similar size and scope. The estimated total number of occupational fatalities for the action alternatives ranges from 0.14 for Alternative 6a to 0.28 for Alternative 7b or 7c; the estimated total cases of occupational injuries range from about 82 to 160. The fatality value is based on the construction industry incidence rate for occupational fatalities; even if this assumption results in underestimating the rate for fatalities occurring during the remedial action period by as much as a factor of 2, the estimated number of occupational fatalities associated with implementing any one of these alternatives would still be below 1. However, such an underestimate appears unlikely because occupational injury rates

for heavy construction are about the same as the average for all construction (U.S. Department of Labor 1988, 1990); also, the average annual incidence rate for fatalities in mining — the industry sector with the highest rate — was 29.0 per 100,000 full-time workers for the period between 1985 and 1988 (U.S. Department of Labor 1988, 1990), which is much less than twice the average rate for construction (namely, 25.2 per 100,000 full-time workers). The estimated number of accidents and fatalities for Alternative 7b or 7c includes accidents associated with off-site transportation of material to the Envirocare or Hanford facility. Transportation-related accidents are considered in more detail in Section F.7.2.

Long-term monitoring and maintenance for the four final action alternatives were assumed to require 2 workers. Over 30 years, 60 person-years of effort would be required, and the estimated total number of occupational fatalities is 0.02. The estimated total cases of occupational injury is 9, of which 4 cases would result in about 85 lost workdays.

F.7 TRANSPORTATION RISK ASSESSMENT

All four action alternatives would require the movement of contaminated and uncontaminated material to and from the Weldon Spring site. Potential impacts from transportation activities are associated with both the nature of the material being transported (e.g., radioactive waste versus treatment supplies) and the possibility of accidents involving injuries and fatalities. A transportation risk assessment was performed to estimate the impacts from transportation of contaminated and uncontaminated material during implementation of any one of the final action alternatives. The assessment used state-of-the-art computational tools, with conservative assumptions when warranted.

The assessment of potential health impacts associated with exposure to contaminants during transportation was limited to radioactive contaminants because the waste was assumed to be packaged in containers and, thus, the major exposure pathway would be external gamma irradiation. Radiological impacts were assessed for truck transportation of radioactive material from Lakes 34, 35, and 36 and the vicinity properties to the site, truck transportation from the site to the Wentzville rail siding, and rail transportation from Wentzville to the Envirocare and Hanford facilities; radiological impacts of off-site transportation are discussed in Sections F.7.3. The transportation risk assessment also included nonexposure-related impacts that are independent of the nature of the cargo, such as fatalities resulting from truck and rail accidents; these impacts are discussed in Section F.7.2.

F.7.1 Summary of Transportation Requirements

The transportation requirements for the final remedial action alternatives are summarized in Table F.23. All of these alternatives would require the movement of both uncontaminated and contaminated material to the Weldon Spring site from off-site sources. Some amount of clean (uncontaminated) soil would be moved in dump trucks to the site from a local borrow source. A potential area for this borrow soil has been identified near Francis

Howell High School; if this area were used, clean soil would generally be transported over distances of less than 2 km (1.2 mi). Contaminated material from Lakes 34, 35, and 36 and from soil vicinity properties would be transported by truck approximately 4 km (2.5 mi) to the site. In addition, under Alternative 6a, uncontaminated fly ash and cement would be trucked to the site from local suppliers within 40 to 160 km (25 to 100 mi).

Movement of material off the Weldon Spring site would be limited to shipment of process chemicals and contaminated material to off-site disposal facilities. For all of the final action alternatives, process chemicals currently in temporary storage on-site would be shipped by truck to a licensed incinerator. For assessment purposes, this incinerator was assumed to be located in Oak Ridge, Tennessee. Under Alternative 7b or 7c, contaminated material would be shipped for final disposal to either the Envirocare facility near Clive, Utah, or the Hanford facility near Richland, Washington. Three types of radioactive material would be transported from the site to a rail siding in Wentzville, Missouri, before being shipped to either the Envirocare or Hanford facility for final disposal: vitrified material (soil and sludge), loose soil/sediment, and volume-reduced building debris. The approximate volumes and radioactivity concentrations of each waste type are given in Table F.24.

The vitrified material would be shipped in compliance with all appropriate radioactive control limits specified in Title 49, Code of Federal Regulations, Part 173 (49 CFR 173). The remaining (nonvitrified) material would have radioactivity levels of less than 2,000 pCi/g and could therefore be transported as material exempt from specific packaging and labeling requirements for transportation of radioactive material. For this assessment, it was assumed that the shipment containers would be similar to those used to haul waste from Grand Junction, Colorado, under the Uranium Mill Tailings Remedial Action Program, except they would be sealed to prevent particulate emissions during transportation. The containers measure 2.4 m × 2.4 m × 3.0 m (8 ft × 8 ft × 10 ft) and can contain about 18 m^3 (24 yd^3) of material.

For the off-site disposal alternatives, the waste materials (i.e., vitrified product, soil/sediment, and volume-reduced building debris) would be loaded into containers at on-site transfer stations and transported by truck to a rail siding in Wentzville. At the rail siding, the containers would be loaded onto 91-t (100-ton) flatcars, three containers per car, and trains of 25 cars would be hauled to either the Envirocare or Hanford disposal facility. Both sites are accessible by a rail siding, at which the containers would be transferred to trucks and transported to the disposal cell. At the disposal cell, the waste materials would be removed from the containers and placed in the cell. The containers would then be externally decontaminated, placed on the rail flatcar, and transported back to the Wentzville siding for unloading and placement on trucks for return to the Weldon Spring site for reuse.

The federal gross vehicle weight limit for truck transportation is 36,000 kg (80,000 lb) (Public Law 97-424, Highway Improvement Act of 1982). A typical tractor-trailer combination weighs approximately 10,900 kg (24,000 lb), so the net freight allowance per truck is limited to 25,100 kg (56,000 lb). The densities of vitrified material, soil/sediment, and volume-reduced building debris would probably limit the volume loading of the containers to 12 m^3 (17 yd^3) for vitrified material and building debris and 14 m^3 (18 yd^3) for soil/sediment.

The total number of truck and railcar shipments required and the one-way haul distances are listed in Table F.23 for each of the final action alternatives. Rail routes from Wentzville to the Envirocare and Hanford facilities were generated with the computer code INTERLINE developed by Oak Ridge National Laboratory (Peterson 1984). The code is based on a shortest path algorithm modified to reflect the nature of U.S. railroad company operations and routing practices and is updated periodically to reflect current track conditions and railroad ownership. The code can be used to calculate shipment routes, distances traveled in each state en route, and fractional distances in urban, suburban, and rural population zones.

F.7.2 Nonexposure-Related Impacts of Transportation

Transportation of any material involves a potential for transportation accidents, independent of the nature of the cargo. Such accidents can result in property damage and/or injuries and fatalities that are not associated with exposure to contaminated material. The expected number of accidents, injuries, and fatalities can be predicted from incident rates based on historical records for the specific transport routes and vehicle types used. The predicted number of occurrences include a contribution from the return of empty vehicles to their point of origin.

All of the final action alternatives are likely to involve some transportation accidents. The estimated transportation-related accidents and fatalities are given in Table F.25. The estimated number of accidents ranges from about 2 for Alternative 7a to about 8 for Alternative 7c, and the estimated number of fatalities is much less than 1 for all of these alternatives.

F.7.3 Radiological Impacts of Transportation

Radiological impacts from transportation of radioactive material occur during routine or "incident-free" transportation and when accidents occur. For incident-free transportation, radiological impacts are associated with penetrating radiation escaping the transport containers, resulting in direct exposure of crew members and persons living near or sharing the transport route. For accident conditions, radiological impacts result from the release and dispersal of radioactive material following an accident, exposing persons externally (to gamma radiation) as well as internally through inhalation of airborne contamination and ingestion of potentially contaminated food grown in soil on which radioactive contaminants had deposited. The radiological impacts from incident-free transportation and transportation accidents are discussed in Sections F.7.3.1 and F.7.3.2, respectively. For both conditions, potential impacts have been estimated collectively for the affected population and individually for the hypothetical maximally exposed individual.

F.7.3.1 Risks from Incident-Free Transportation

Radiological impacts during incident-free transportation result from exposure to the external radiation field surrounding the shipment containers. The dose is a function of the number of people exposed, their proximity to the containers, the length of time of exposure, vehicle speed, and the radiation field strength surrounding the containers.

The magnitude of the risk from external exposure to penetrating radiation depends primarily on the external dose rate of the shipping container. Package external radiation field strengths for various classifications of radioactive wastes, as defined in 49 CFR 173, are typically expressed in terms of dose rate (mrem/h) at 1 m from the package surface, a value referred to as the transport index (TI). For this analysis, the external dose rate surrounding a loaded container was calculated from information in Chen et al. (1981), and it was based on the radioactive and physical characteristics of the waste material. The TI was calculated as 0.3 mrem/h for vitrified material. For soil/sediment and building debris, which are exempt from the packaging and labeling requirements of 49 CFR 173, an equivalent TI of 0.1 mrem/h was calculated.

The RADTRAN 4 computer code (Neuhauser and Kanipe 1991) was used to calculate the radiological risks from incident-free transportation. The RADTRAN risk assessment model was developed by Sandia National Laboratories to calculate radiological risks associated with transportation of radioactive material by a variety of modes, including truck, rail, and barge. Specific parameters used in this analysis of incident-free impacts are presented in Table F.26. Parameter values are based on operational experience and scenario-specific assumptions.

Radiological impacts were determined separately for truck and rail crews, handlers at the Wentzville transfer station, and members of the general public. For each of these categories, doses and risks were estimated for both maximally exposed individuals and the affected population. Members of the public include residents living adjacent to the transport routes, persons sharing the transport routes, and persons at stops (e.g., refueling stops). The maximally exposed member of the public was defined as a resident living 30 m (100 ft) from the transport route who is present at the residence during every shipment pass; to be conservative, the shielding afforded by vehicles or housing was not included in this calculation.

The dose to maximally exposed individuals is highly dependent upon the external dose rate of the loaded containers. To conservatively estimate maximum annual doses, crew members and waste handlers were assumed to be involved only with shipments of vitrified material. The doses calculated for maximally exposed individuals therefore represent upper bounds for the expected values. Furthermore, crewmen and handlers were assumed to work 8 hours per day, 250 days per year, for the duration of transportation activities. Each truck crew member was assumed to make five trips per day to the Wentzville siding, and each rail crew member was assumed to make 32 shipments per year, based on an 8-day train cycle. Each handler was assumed to operate a transfer and transfer 33 containers per day from trucks to waiting railcars at a distance of 4 m (12 ft) from each container. The collective dose to workers was based on the waste inventory given in Table F.24.

The impacts from incident-free transportation of contaminated material are presented in Table F.27. All doses to maximally exposed crew members and members of the general public are considerably below the limits specified in DOE Orders 5480.11 and 5400.5. For both off-site disposal alternatives, the dose to the maximally exposed member of the public is estimated to be 0.11 mrem, which is significantly less than the dose limit of 100 mrem/yr specified in DOE Order 5400.5. The dose to the maximally exposed crew member is estimated to be 0.013 rem/yr for Alternative 7b and 0.017 rem/yr for Alternative 7c, and the dose to the maximally exposed handler is estimated to be approximately 0.1 rem/yr; these doses are all well below the occupational dose limit of 5 rem/yr specified in DOE Order 5480.11. In addition, the doses received by handlers would likely be less than this value because of the conservative assumptions incorporated in this assessment. Moreover, these doses could be reduced further by implementing procedures such as limiting the number of hours worked and installing area shielding, as indicated by monitoring results during implementation.

Transportation of the entire volume of contaminated material from the site to Wentzville would result in a population dose of about 0.12 person-rem. The population doses do not differ significantly for rail transportation to the Envirocare or Hanford facility. The estimated population doses are 4.4 and 5.8 person-rem for transportation to Envirocare and Hanford, respectively. The collective worker dose is estimated to be 1.5 person-rem for either Alternative 7b or Alternative 7c. In all cases, the collective risk to the impacted population of about 600,000 from incident-free transportation is much less than 1 for the entire shipment campaign.

F.7.3.2 Risks from Transportation Accidents

The radiological doses and subsequent health risks associated with transportation accidents were estimated by multiplying the radiation doses associated with an accident by the probability of occurrence of that accident. In this analysis, the radiological risk from all potential accidents involving off-site transportation of radioactive material was assessed for the general population and for a maximally exposed individual. It was assumed that the maximally exposed individual would reside 100 m (330 ft) from the accident site and consume only locally grown food for 1 year. The RADTRAN 4 computer code (Neuhauser and Kanipe 1991) was used for the population assessment and the GENII computer code (Napier et al. 1988) for the maximally exposed individual. Radiological doses were calculated for the following pathways:

- Inhalation of airborne contaminants,
- External exposure from contaminants on the ground,
- External exposure from a passing radioactive cloud, and
- Ingestion of garden produce grown in soil in which radioactive contaminants had deposited.

To analyze the maximum possible consequences of an accident, it was assumed that all of the material in a given shipment would be spilled during an accident. Thus, a truck accident would involve the dumping of one container, and a rail accident would involve the dumping of 75 containers. The fraction of material released following an accident that would become airborne and would be respirable was estimated from the emission factor equations given in EPA (1988a). It was assumed that the spilled material was relatively dry soil and sediment (10% moisture by weight) and was spilled from a height of 3 m (10 ft). The fraction of spilled material that would become respirable was calculated to be 5×10^{-6}. It was determined that accidents involving vitrified material and building debris and rubble would not contribute significantly to the radiological risks associated with accidents because the estimated release fractions for these materials are several orders of magnitude less than the values for soil and sediment.

Potential impacts from truck transport of material to the Wentzville rail siding were based on an accident rate of 1.36×10^{-6} per vehicle-km for U.S.-numbered routes in Missouri (Brocksmith 1991). Potential impacts from rail transport from the Wentzville siding to the off-site disposal facility (either Envirocare or Hanford) were based on a rail accident rate of 5.57×10^{-8} per railcar-km. This rail accident rate is the national average mainline accident rate for the years 1986 through 1988 and is based on the most recent information available from the Federal Railroad Administration Office of Safety (Saricks 1991b).

The dispersion of contaminants through the environment is dependent upon the meteorological conditions at the time of release. For this analysis, average annual meteorological data for each state traversed during transport were taken from stability array (STAR) data available from the National Climatic Data Center. Each stability array contains frequencies of the wind blowing from a particular direction at a particular stability and particular speed. For each route, the STAR data for each state traversed were weighted by the distance traveled in that state, and a composite "route average" meteorological file was created.

The assessment of risks for the affected population and for the maximally exposed individual differed with regard to the radionuclide content of shipment containers. To assess the population risk, an average radioactivity concentration was calculated for each radionuclide, assuming that the soil/sediment from all sources was homogenized; thus, the population analysis represents a risk averaged over all shipments. To assess the maximally exposed individual risk, it was conservatively assumed that an accident would involve the release of material containing the maximum concentration of each contaminant, even though the maximum contaminant concentrations for the radionuclides of interest are not present together in any one material. This assumption is expected to bound potential impacts to the maximally exposed individual. The inventory of radionuclides used for the accident risk assessment are given Table F.28. The resulting radiological impacts from accidents involving transportation of radioactive material to the Wentzville siding by truck and to the Envirocare and Hanford facilities by rail are presented in Table F.29.

The dose to the maximally exposed individual following an accident is estimated to be 0.64 mrem for shipment to Wentzville and 48 mrem for shipment to either Clive or Hanford (Table F.29). About 60% of the dose would result from inhalation of airborne contaminants

during passage of the plume following an accident. Ingestion of contaminated food would contribute most of the remainder. The risk of cancer induction from these exposures is approximately 4×10^{-7} for shipment to Wentzville and 3×10^{-5} for shipment to either Clive or Hanford.

The population risk estimated from average meteorological and accident data ranges from 0.0030 to 0.41 person-rem, and the associated risk ranges from 2×10^{-6} to 2×10^{-4} (Table F.29). The radiological risks from transportation accidents are small compared with those from incident-free operations (due to the low probability of an accident occurring) and the nonexposure-related consequences of accidents (i.e., fatalities). These accident risk calculations are conservative because (1) shielding and air filtration afforded by housing were not included, (2) post-accident remedial activities that would reduce the consequences of an accident, such as ground cleanup, were not considered, and (3) the maximally exposed individual was assumed to remain unprotected 100 m (330 ft) from the accident site for an entire year and consume only locally grown food.

F.8 COMPARISON OF POTENTIAL HEALTH IMPACTS FOR THE FINAL REMEDIAL ACTION ALTERNATIVES

The potential health impacts for the four final action alternatives are summarized in Table F.30; impacts associated with the no-action alternative are discussed in detail in the BA (DOE 1992a) and in the rebaseline assessment presented in Appendix E. The results indicate that all exposures to remedial action workers and members of the general public would remain significantly below pertinent regulatory limits for any one of these alternatives. These calculations were based on reasonable, but conservative, scenario definitions and assumptions; more realistic risk estimates for both workers and members of the public would probably be lower than those presented here.

For all four final action alternatives, the general public could be exposed to radioactive and chemical contaminants released from the site via airborne dust and gaseous emissions. Routine cleanup activities that could result in the generation of fugitive dust and gases include waste excavation, treatment, loading/unloading, and grading and compaction. Airborne releases of contaminated material from accidents occurring on-site would be small compared with releases from routine activities and thus have not been explicitly quantified in this analysis.

Inhalation of airborne contaminants is the most probable route of exposure to site releases for the general public during the remedial action period. Although the major treatment facilities — i.e., the chemical stabilization/solidification facility for Alternative 6a or the vitrification facility for Alternatives 7a, 7b, and 7c — differ fundamentally in design, atmospheric particulate releases would not differ significantly for the four action alternatives. In general, the same waste would be treated under the respective treatment processes for each alternative, the treatment facilities would be enclosed, and particulate releases would be controlled by collection systems such as air particulate filters. Radon gas emissions would be approximately 40% higher for the vitrification alternatives because more radon would be released during the vitrification process. However, the risk assessment results indicate that potential health impacts to the

general public for the four action alternatives would be comparable; no incremental impacts are predicted at the nearby off-site receptor locations for the general public. The health risks to the maximally exposed member of the public are estimated to be approximately 7×10^{-7} and 9×10^{-8} for radioactive and chemical contaminants, respectively. These estimates are below EPA's target range of 1×10^{-6} to 1×10^{-4}. For comparison, the risk of developing cancer from exposure to naturally occurring background radiation is about 2×10^{-4} annually, or about 1×10^{-3} over the same 7-year period.

The estimated work force requirements for the four final action alternatives range from 560 person-years for Alternative 6a to 1,100 person-years for Alternatives 7b and 7c. The potential occupational impacts associated with the specific handling and treatment processes would be similar for the four alternatives. The collective health risks to the maximally exposed remedial action worker are estimated to be approximately 1×10^{-3} and 8×10^{-5} for radioactive and chemical contaminants, respectively. All exposures to contaminants would be well below applicable regulatory limits. On the basis of statistics for construction activities of comparable size and scope, no occupational fatalities are projected to occur for any one of the final action alternatives. The number of occupational injuries is estimated to range from 82 to 160.

In addition to impacts associated with site releases during cleanup activities, Alternatives 7b and 7c would require the transportation of contaminated material off-site for disposal, which would result in an incremental risk to transportation workers and to the general public along the route. The radiological impacts to the general public associated with transportation activities would be similar for Alternative 7b or 7c and would be significantly less than those estimated for the vicinity of the Weldon Spring site from releases generated during on-site treatment and handling activities. The risk to the maximally exposed member of the public from transportation activities is estimated to be 7×10^{-8}. The radiological risks to transportation workers would also be similar for Alternative 7b or 7c and would be significantly less than those projected for on-site remedial action workers. The risk to the maximally exposed transportation worker is estimated to be 2×10^{-4}.

Potential occupational exposures to contaminants would be minimized by conducting remedial action activities in accordance with all applicable requirements and health and safety plans developed for the Weldon Spring site. Moreover, DOE is committed to controlling all radiation exposures and releases of radioactive material to the environment to levels as low as reasonably achievable, as specified in DOE Orders 5480.11 and 5400.5. Transportation activities would be conducted in compliance with all appropriate shipping, packaging, and labeling requirements, including those specified for radioactive material in 49 CFR 173. In summary, any one of these four alternatives could be implemented in a manner that would ensure that both occupational and general public exposures during the remedial action period would be significantly below applicable regulatory limits established to ensure health and safety.

TABLE F.1 Potential Receptors near the Weldon Spring Site

	Receptor	Location Relative to the Site Center	Scenario Description[a]
A	Nearby resident (janitor at Francis Howell High School)	1.4 km ENE	An individual is present at the residence 100% of the time during the 7-year cleanup period.
B	Nearby resident (Department of Conservation employee)	1.5 km WNW	Same as receptor A.
C	Nearby resident (adjacent to U.S. Route 40/61)	2.7 km NE	Same as receptor A.
D	Nearby resident (Weldon Spring Heights)	3.7 km ENE	Same as receptor A.
E	Student (Francis Howell High School)	1.2 km ENE	A student is present at Francis Howell High School 8 hours per day, 180 days per year, during 4 years of the cleanup period.[b]
F	Child (daycare facility at the former Weldon Spring Elementary School)[c]	3.2 km NE	A child is present at the daycare facility 8 hours per day, 60 days per year, during the 7-year cleanup period.
G	Worker (highway maintenance facility)	0.6 km E	A worker is present at the highway maintenance facility 8 hours per day, 250 days per year, during the 7-year cleanup period.
H	Worker (Army Reserve Training Area)	1.0 km SSW	Same as receptor G.
I	Worker (employee at Busch Wildlife Area headquarters)	1.2 km NW	Same as receptor G.
J	Worker (on-site office building)	0.4 km SE	A worker is present at the Weldon Spring site 8 hours per day, 250 days per year, during the 7-year cleanup period.
K	Remedial action worker	Variable[d]	Same as receptor J.

[a] The cleanup period is projected to comprise 7 years of the 10-year remedial action period (which includes remedial action planning, design, and start-up).

[b] A teacher at Francis Howell High School would have an exposure scenario similar to other nearby workers — e.g., receptors G, H, I, and J — except that the exposure time would probably be less than 250 days per year.

[c] Although the daycare facility was recently destroyed by fire, this receptor location was retained for this assessment to address the possibility that the facility might be rebuilt for a similar use.

[d] The worker would be present at various on-site locations during the remedial action period.

TABLE F.2 Exposure Scenario Assumptions and Intake Parameters[a]

Parameter	Residents (Receptors A, B, C, D)	High School Student (Receptor E)	Child (Receptor F)	Off-Site Workers (Receptors G, H, I)	On-Site Worker (Receptor J)	Remedial Action Worker (Receptor K)
Average body weight[b] (kg)	70	60	30	70	70	70
Exposure time[c] (h/d)						
Indoor	23	7	6	4	8	0
Outdoor	1	1	2	4	0	8
Exposure frequency[c] (d/yr)	350	180	60	250	250	250
Exposure duration[c] (yr)	7	4	7	7	7	7
Inhalation rate[d] (m^3/h)						
Indoor	0.8	1.1	1.4	1.0	1.0	NA
Outdoor	1.6	2.5	1.9	2.5	NA	2.5
Indoor air filtration	0.8	0.8	0.8	0.8	0.8	NA
Soil ingestion rate[e] (mg/d)	100	50	100	120	50	300
Food ingestion rate[f] (g/d)	122	NA	NA	NA	NA	NA

[a] NA means that the entry is not applicable.

[b] The average body weights for the residents and workers are the standard values given in EPA (1991a); for the other receptors, the body weights were estimated on the basis of the age of the receptor and information provided in EPA (1989d).

[c] Estimates of exposure time, exposure frequency, and exposure duration are based on the assumed activity patterns of the receptors. Where appropriate, these values are consistent with those given in EPA (1991a). The cleanup period is projected to comprise 7 years of the 10-year remedial action period.

[d] The inhalation rates for the residents and remedial action worker are the standard values given in EPA (1991a); for the other receptors, the inhalation rates were derived from assumed activity levels and information provided in EPA (1989d).

[e] The soil ingestion rates for the residents and on-site office worker are the standard values given in EPA (1991a); the ingestion rate for the high school student was assumed to be the same as that of the office worker, and both are based on the relative proportion of time spent on or near the site. For a child aged 6 through 12, the total daily intake of 100 mg/d (EPA 1991a) was assumed to occur while at the daycare center. Ingestion rates for the off-site workers (receptors G, H, and I) and remedial action worker (receptor K) are based on the same assumptions as those presented for the ranger in Appendix E (Section E.3.1.2); a higher rate was derived for the remedial action worker because of longer exposure to contaminated material (8 hours per day compared with 4 hours per day) and ingestion of inhaled material that is not retained in the lungs.

[f] The food ingestion rate represents ingestion of 42 g/d of fruits and 80 g/d of vegetables, which are the standard values given in EPA (1991a).

TABLE F.3 Estimated Concentrations of Radionuclides in Material Targeted for Treatment[a]

Contaminant	Concentration[b] (pCi/g)		
	Raffinate Pit Sludge[c]	Soil under Raffinate Pits[c]	Quarry Soil in TSA[d]
Actinium-227	1,300	130	0.58
Lead-210	1,400	140	340
Protactinium-231	1,700	170	1.2
Radium-226	1,400	140	110
Radium-228	560	56	96
Thorium-230	58,900	5,800	330
Thorium-232	60	6.0	26
Uranium-235	110	11	9.2
Uranium-238	2,300	230	200
Estimated volume (yd^3)	220,000	50,000	50,000

[a] The contaminated areas were divided into two categories: those for which chemical treatment or vitrification is expected (i.e., the more highly contaminated material) and those for which treatment is not expected; the estimated concentrations for the latter are presented in Table F.4.

[b] All values were calculated on a dry weight basis and are given to two significant figures. Because not all radionuclides were measured for the various source areas, the activity concentration ratios given in Table 2.3 of the BA were used to estimate the concentrations of those radionuclides.

[c] The UL_{95} concentrations (i.e., the 95% upper confidence limits of the arithmetic averages) were used for measured radionuclides; the source term analysis for the raffinate pit sludge was used to estimate the concentrations of radionuclides not measured. The radionuclide concentrations in soil under the raffinate pits were assumed to be 10% of those in the raffinate pit sludge.

[d] The average concentrations were used for measured radionuclides (DOE 1989); the radiological source term analysis for the quarry soil (Table 2.3 of the BA) was used to estimate the concentrations of radionuclides not measured.

TABLE F.4 Estimated Concentrations of Radionuclides in Areas Targeted for Excavation[a]

Contaminant	Concentration[b] (pCi/g)						
	Sediment/ Soil at Ash Pond[c,d]	Soil at North Dump[c]	Sediment/ Soil at Frog Pond[e]	Soil around Raffinate Pits[f]	Soil around Chemical Plant Buildings[g]	Sediment/ Shoreline Soil at Busch Lakes[h]	Soil at Vicinity Properties[i]
Actinium-227	3.6	2.5	1.2	0.63	0.42	0.57	2.0
Lead-210	26	18	11	4.6	3.1	4.2	44
Protactinium-231	7.2	5.0	2.5	1.3	0.83	1.1	4.1
Radium-226	26	18	11	4.6	3.1	4.2	43
Radium-228	14	9.9	5.9	2.5	1.7	2.3	7.9
Thorium-230	29	20	5.2	5.0	3.3	4.5	24
Thorium-232	14	9.9	5.9	2.5	1.7	2.3	7.9
Uranium-235	8.6	6.0	3.0	1.5	1.0	1.4	4.8
Uranium-238	190	130	65	33	22	30	110
Estimated volume (yd^3)	25,100	7,600	7,000	103,500	87,100[j]	20,000	3,600

See next page for footnotes.

TABLE F.4 (Cont.)

[a] The contaminated areas were divided into two categories: those for which chemical treatment or vitrification is expected (i.e., the more highly contaminated material) and those for which treatment is not expected; the estimated concentrations for the former are presented in Table F.3. This table does not include material assumed to be in temporary storage (e.g., at the TSA and MSA) nor areas that might become contaminated as a result of implementing one of the action alternatives.

[b] All values were calculated on a dry weight basis and are given to two significant figures. Because not all radionuclides were measured for the various source areas, the activity concentration ratios given in Table 2.3 of the BA were used to estimate the concentrations of those radionuclides.

[c] The kriging method was used to estimate the area-weighted average concentration of uranium-238; the radiological source term analysis for soil at the chemical plant area was used to estimate the concentrations of other radionuclides.

[d] The Ash Pond concentrations and volume include the contribution from the South Dump; these areas were treated as a single source area because they are located in proximity and are part of the same drainage system.

[e] Only the drainage from Frog Pond has been sampled to date; the average concentration of uranium-238 in this drainage is about 30 pCi/g. For this reason, the sitewide soil UL_{95} radionuclide concentrations were used for this area.

[f] The kriging results indicate that only thorium-230 concentrations are above the preliminary cleanup criterion (i.e., 2,400 m^3 [3,100 yd^3] of soil at a concentration of 5 pCi/g). For conservatism, it was assumed that the entire volume has a thorium-230 concentration of 5 pCi/g; the radiological source term analysis for soil at the chemical plant area was used to estimate the concentrations of other radionuclides.

[g] The kriging results indicate that 6,200 m^3 (8,100 yd^3) of soil is contaminated with uranium-238 at an average concentration of 220 pCi/g. This concentration was adjusted to reflect the volume estimate for actual field excavation provided in MK-Ferguson Company and Jacobs Engineering Group (1992). The radiological source term analysis for soil at the chemical plant area was used to estimate the concentrations of other radionuclides.

[h] Determined from the estimated concentration of uranium-238 in the lake sediment; the radiological source term analysis for soil at the chemical plant area was used to estimate the concentrations of other radionuclides.

[i] Determined from the concentrations for the vicinity properties given in Table F.24.

[j] Includes soil around the chemical plant buildings, soil beneath the buildings, soil around pipes and sewers, and soil in the site water treatment plant area.

TABLE F.5 Estimated Concentrations of Chemicals in Material Targeted for Treatment[a]

Contaminant	Concentration[b] (mg/kg)		
	Raffinate Pit Sludge[c]	Soil under Raffinate Pits[c]	Quarry Soil in TSA[d]
Metals			
Antimony	110	11	-[e]
Arsenic	1,600	160	100
Barium	1,400	140	-
Beryllium	33	3.3	0.62
Cadmium	54	5.4	19
Chromium	87	8.7	30
Cobalt	34	3.4	-
Copper	740	74	180
Lead	530	53	280
Lithium	65	6.5	-
Manganese	3,600	360	-
Mercury	6.6	0.66	2.0
Molybdenum	2,800	280	-
Nickel	1,100	110	43
Selenium	77	7.7	23
Silver	3.5	0.35	7.0
Thallium	26	2.6	4.7
Uranium[f]	6,900	690	600
Vanadium	12,000	1,200	-
Zinc	700	70	340
Inorganic anions			
Fluoride	73	7.3	-
Nitrate	120,000	12,000	-
Nitrite	1,200	120	-
PAHs[g]	-	-	180
PCBs[h]	2,700	270	32
Nitroaromatic compounds[i]			
DNB	-	-	-
2,4-DNT	-	-	8.1
2,6-DNT	-	-	9.5
NB	-	-	78
TNB	-	-	140
TNT	-	-	260
Estimated volume (yd^3)	220,000	50,000	50,000

See next page for footnotes.

TABLE F.5 (Cont.)

[a] The contaminated areas were divided into two categories: those for which chemical treatment or vitrification is expected (i.e., the more highly contaminated material) and those for which treatment is not expected; the estimated concentrations for the latter are presented in Table F.6.

[b] All values were calculated on a dry weight basis and are given to two significant figures.

[c] The UL_{95} concentrations were used for chemicals in the raffinate pit sludge. The contaminant concentrations in soil under the raffinate pits were assumed to be 10% of those in the raffinate pit sludge.

[d] The average concentrations from available data were used for the chemical contaminants in the quarry soil (DOE 1989).

[e] A hyphen indicates that the contaminant was not detected above the detection limit.

[f] The concentrations of uranium are based on the uranium-238 concentrations presented in Table F.3.

[g] Includes acenaphthene, anthracene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene.

[h] Includes Aroclor 1248, 1254, and 1260.

[i] DNB = 1,3-dinitrobenzene; 2,4-DNT = 2,4-dinitrotoluene; 2,6-DNT = 2,6-dinitrotoluene; NB = nitrobenzene; TNB = 1,3,5-trinitrobenzene; TNT = trinitrotoluene.

TABLE F.6 Estimated Concentrations of Chemicals in Areas Targeted for Excavation[a]

Contaminant	Concentration[b] (mg/kg)				
	Sediment/ Soil at Ash Pond[c]	Soil at North Dump	Sediment/ Soil at Frog Pond	Soil around Raffinate Pits	Soil around Chemical Plant Buildings
Metals					
Antimony	8.2	2.7	32	9.0	53
Arsenic	28	19	20	69	17
Barium	230	280	220	330	280
Beryllium	1.3	0.18	1.3	1.3	1.3
Cadmium	1.8	0.18	6.2	0.79	0.74
Chromium	46	10	31	39	32
Cobalt	12	7.1	15	17	13
Copper	39	6.8	18	15	34
Lead	100	190	88	21	27
Lithium	10	1.8	47	11	12
Manganese	880	1,500	940	1,700	810
Mercury	0.73	0.035	0.050	0.16	0.069
Molybdenum	26	9.2	30	2.3	27
Nickel	60	12	42	26	42
Selenium	15	0.18	0.25	0.25	1.8
Silver	2.4	0.35	7.1	0.50	1.1
Thallium	3.9	1.6	0.50	1.4	0.50
Uranium[d]	570	390	200	99	66
Vanadium	44	19	44	48	53
Zinc	160	19	830	55	120
Inorganic anions					
Fluoride	8.4	7.8	6.1	9.4	8.4
Nitrate	5.5	6.0	26	570	3.3
Nitrite	0.25	0.37	0.25	0.25	0.29
PAHs[e]	[f]	-	-	-	4.0
PCBs[g]	0.037	-	-	-	0.002
Nitroaromatic compounds					
DNB	-	-	-	0.67	3.0
2,4-DNT	-	-	-	-	-
2,6-DNT	-	-	-	-	-
NB	-	-	-	-	-
TNB	-	-	-	-	-
TNT	0.96	-	-	-	-
Estimated volume (yd^3)	25,100	7,600	7,000	103,500	87,100[h]

See next page for footnotes.

TABLE F.6 (Cont.)

[a] The contaminated areas were divided into two categories: those for which chemical treatment or vitrification is expected (i.e., the more highly contaminated material) and those for which treatment is not expected; the estimated concentrations for the former are presented in Table F.5.

[b] All values were calculated on a dry weight basis and are given to two significant figures.

[c] The Ash Pond concentrations and volume include the contribution from the South Dump; these areas were treated as a single source area because they are located in proximity and are part of the same drainage system.

[d] The concentrations of uranium are based on the uranium-238 concentrations presented in Table F.4.

[e] Includes acenaphthene, anthracene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene.

[f] A hyphen indicates that the contaminant was not detected above the detection limit.

[g] Includes Aroclor 1248, 1254, and 1260.

[h] The kriging method was used to estimate the area-weighted average concentration of uranium-238; the radiological source term analysis for soil at the chemical plant area was used to estimate the concentrations of other radionuclides.

TABLE F.7 Estimated Average Airborne Concentrations of Radionuclides at Receptor Locations during the 7-Year Cleanup Period for Alternative 6a, Chemical Stabilization/Solidification, and Alternative 7a, Vitrification

Alternative/ Contaminant	Estimated Concentration of Respirable Particulates in Air at Receptor Locations[a] (pCi/m^3, except as noted)											Concentration Limits[b] (pCi/m^3)	
	A	B	C	D	E	F	G	H	I	J	K	DCG	DAC
Chemical Stabilization/Solidification													
Actinium-227	1.1×10^{-9}	1.3×10^{-7}	4.5×10^{-8}	1.8×10^{-8}	1.3×10^{-7}	4.3×10^{-8}	3.6×10^{-7}	5.4×10^{-7}	3.4×10^{-7}	9.6×10^{-7}	1.2×10^{-3}	7×10^{-3}	7×10^{-1}
Lead-210	4.7×10^{-7}	5.9×10^{-7}	1.5×10^{-7}	7.6×10^{-8}	5.4×10^{-7}	1.5×10^{-7}	1.5×10^{-6}	3.1×10^{-6}	1.1×10^{-6}	3.9×10^{-6}	1.1×10^{-2}	9×10^{-1}	1×10^{2}
Protactinium-231	1.5×10^{-7}	1.8×10^{-7}	6.3×10^{-8}	2.5×10^{-8}	1.8×10^{-7}	5.9×10^{-8}	5.2×10^{-7}	7.3×10^{-7}	4.5×10^{-7}	1.4×10^{-6}	2.5×10^{-3}	9×10^{-3}	7×10^{-1}
Radium-226	3.0×10^{-7}	3.5×10^{-7}	1.1×10^{-7}	4.9×10^{-8}	3.5×10^{-7}	1.0×10^{-7}	1.1×10^{-6}	1.5×10^{-6}	6.7×10^{-7}	3.1×10^{-6}	1.1×10^{-2}	3	5×10^{2}
Radium-228	1.8×10^{-7}	2.1×10^{-7}	5.9×10^{-8}	2.9×10^{-8}	2.0×10^{-7}	5.7×10^{-8}	6.2×10^{-7}	1.0×10^{-6}	3.7×10^{-7}	1.7×10^{-6}	5.9×10^{-3}	1	3×10^{2}
Thorium-230	4.5×10^{-4}	5.7×10^{-6}	1.9×10^{-6}	7.2×10^{-7}	5.3×10^{-6}	1.8×10^{-6}	1.4×10^{-5}	2.5×10^{-5}	1.5×10^{-5}	3.4×10^{-5}	5.2×10^{-3}	7×10^{-3}	5×10^{-1}
Thorium-232	8.9×10^{-8}	8.7×10^{-8}	3.0×10^{-8}	1.5×10^{-8}	1.1×10^{-7}	2.6×10^{-8}	3.9×10^{-7}	3.3×10^{-7}	1.3×10^{-7}	1.2×10^{-6}	5.9×10^{-3}	4×10^{-2}	3
Uranium-235	5.4×10^{-8}	5.3×10^{-8}	1.9×10^{-8}	8.9×10^{-9}	6.4×10^{-8}	1.6×10^{-8}	2.3×10^{-7}	1.9×10^{-7}	8.6×10^{-8}	7.2×10^{-7}	3.0×10^{-3}	1×10^{-1}	2×10^{1}
Uranium-238	1.2×10^{-6}	1.1×10^{-6}	4.1×10^{-7}	1.9×10^{-7}	1.4×10^{-6}	3.6×10^{-7}	5.1×10^{-6}	4.0×10^{-6}	1.9×10^{-6}	1.6×10^{-5}	6.5×10^{-2}	1×10^{-1}	2×10^{1}
Radon-222[c]	8.4×10^{-4}	2.0×10^{-3}	3.5×10^{-4}	2.3×10^{-4}	9.1×10^{-4}	2.7×10^{-4}	2.1×10^{-3}	3.1×10^{-3}	2.0×10^{-3}	8.1×10^{-3}	NA	3×10^{3}	3×10^{4}
Radon-222[d]	2.8×10^{-6}	6.3×10^{-6}	1.4×10^{-6}	9.1×10^{-7}	3.0×10^{-6}	1.1×10^{-6}	6.7×10^{-6}	9.5×10^{-6}	6.0×10^{-6}	2.3×10^{-5}	1.0×10^{-3}	NA	0.33
Vitrification													
Actinium-227	7.3×10^{-8}	1.6×10^{-7}	3.0×10^{-8}	1.1×10^{-8}	9.0×10^{-8}	2.8×10^{-8}	2.4×10^{-7}	5.1×10^{-7}	2.9×10^{-7}	6.8×10^{-7}	1.2×10^{-3}	7×10^{-3}	7×10^{-1}
Lead-210	8.1×10^{-6}	9.3×10^{-6}	3.0×10^{-6}	2.6×10^{-6}	8.5×10^{-6}	3.0×10^{-6}	1.2×10^{-5}	1.3×10^{-5}	1.0×10^{-5}	2.2×10^{-5}	1.1×10^{-2}	9×10^{-1}	1×10^{2}
Protactinium-231	1.1×10^{-7}	2.2×10^{-7}	4.3×10^{-8}	1.6×10^{-8}	1.3×10^{-7}	3.9×10^{-8}	3.6×10^{-7}	6.9×10^{-7}	4.0×10^{-7}	1.1×10^{-6}	2.5×10^{-3}	9×10^{-3}	7×10^{-1}
Radium-226	2.5×10^{-7}	3.8×10^{-7}	9.6×10^{-8}	4.6×10^{-8}	2.9×10^{-7}	7.7×10^{-8}	9.3×10^{-7}	1.6×10^{-6}	6.3×10^{-7}	3.2×10^{-6}	1.1×10^{-2}	3	5×10^{2}
Radium-228	1.8×10^{-7}	2.2×10^{-7}	5.7×10^{-8}	3.0×10^{-8}	1.7×10^{-7}	4.5×10^{-8}	5.4×10^{-7}	1.1×10^{-6}	3.6×10^{-7}	1.8×10^{-6}	5.9×10^{-3}	1	3×10^{2}
Thorium-230	2.8×10^{-6}	6.9×10^{-6}	1.2×10^{-6}	4.6×10^{-7}	3.5×10^{-6}	1.1×10^{-6}	8.2×10^{-6}	2.4×10^{-5}	1.3×10^{-5}	2.0×10^{-5}	5.2×10^{-3}	7×10^{-3}	5×10^{-1}
Thorium-232	8.5×10^{-8}	9.5×10^{-8}	3.0×10^{-8}	1.5×10^{-8}	9.9×10^{-8}	2.3×10^{-8}	3.6×10^{-7}	3.8×10^{-7}	1.4×10^{-7}	1.4×10^{-6}	5.9×10^{-3}	4×10^{-2}	3
Uranium-235	5.0×10^{-8}	5.9×10^{-8}	1.8×10^{-8}	8.4×10^{-9}	5.9×10^{-8}	1.4×10^{-8}	2.2×10^{-7}	2.0×10^{-7}	8.9×10^{-8}	8.4×10^{-7}	3.0×10^{-3}	1×10^{-1}	2×10^{1}
Uranium-238	1.1×10^{-6}	1.3×10^{-6}	3.9×10^{-7}	1.8×10^{-7}	1.3×10^{-6}	3.1×10^{-7}	4.8×10^{-6}	4.4×10^{-6}	1.9×10^{-6}	1.8×10^{-5}	6.5×10^{-2}	1×10^{-1}	2×10^{1}
Radon-222[c]	1.2×10^{-3}	2.8×10^{-3}	5.0×10^{-4}	3.3×10^{-4}	1.3×10^{-3}	3.9×10^{-4}	3.0×10^{-3}	4.5×10^{-3}	2.8×10^{-3}	1.2×10^{-2}	NA	3×10^{3}	3×10^{4}
Radon-222[d]	4.1×10^{-6}	9.0×10^{-6}	2.0×10^{-6}	1.3×10^{-6}	4.3×10^{-6}	1.6×10^{-6}	9.5×10^{-6}	1.4×10^{-5}	8.5×10^{-6}	3.4×10^{-5}	1.0×10^{-3}	NA	0.33

[a] The potential receptors are described in Table F.1, and their locations are shown in Figure F.1. Except for receptor K, the airborne concentrations of radionuclides were calculated from the estimated annual average respirable particulate concentrations originating from contaminated sources and the contaminant concentrations in those sources. The concentrations of radon gas are based on total estimated releases of radon gas during remedial action activities (see text). For receptor K, the airborne concentrations of radionuclides are based on a respirable particulate concentration of 1 mg/m^3 and the UI_{95} radionuclide concentrations in sitewide soil.

[b] Limits for protection from airborne radioactive contaminants; DCG = derived concentration guide (for protection of the general public); DAC = derived air concentration (for protection of workers). The DCGs and DACs given in this table are for the most conservative lung clearance class of the specific radionuclides (see Appendix G, Table G.2). Because the radiation dose includes the contributions from various decay products of these radionuclides, compliance with dose standards cannot be determined on the basis of the data in this table.

[c] Reported in pCi/L; NA for receptor K means not applicable because the radon concentration, in WL units, was used for the exposure estimate.

[d] Reported in WL; NA for DCG means not applicable because no DCG is currently available in WL units.

TABLE F.8 Estimated Average Airborne Concentrations of Chemicals at Receptor Locations during the 7-Year Cleanup Period for Alternative 6a, Chemical Stabilization/Solidification

	Estimated Concentration of Respirable Particulates in Air at Receptor Locations[a] (mg/m³)										
Contaminant	A	B	C	D	E	F	G	H	I	J	K
Metals											
Antimony	7.9×10^{-10}	4.7×10^{-10}	2.3×10^{-10}	1.1×10^{-10}	9.7×10^{-10}	2.1×10^{-10}	4.7×10^{-9}	1.9×10^{-9}	6.8×10^{-10}	1.7×10^{-8}	7.2×10^{-6}
Arsenic	5.5×10^{-10}	5.5×10^{-10}	2.0×10^{-10}	8.6×10^{-11}	6.5×10^{-10}	1.8×10^{-10}	2.4×10^{-9}	2.4×10^{-9}	1.1×10^{-9}	7.3×10^{-9}	1.9×10^{-5}
Barium	5.1×10^{-9}	3.6×10^{-9}	1.7×10^{-9}	7.9×10^{-10}	6.2×10^{-9}	1.4×10^{-9}	2.8×10^{-8}	1.3×10^{-8}	5.9×10^{-9}	9.4×10^{-8}	1.9×10^{-4}
Beryllium	2.4×10^{-11}	1.7×10^{-11}	7.5×10^{-12}	3.5×10^{-12}	2.9×10^{-11}	6.9×10^{-12}	1.3×10^{-10}	7.1×10^{-11}	3.1×10^{-11}	4.4×10^{-10}	1.0×10^{-6}
Cadmium	3.0×10^{-11}	3.4×10^{-11}	9.6×10^{-12}	4.7×10^{-12}	3.6×10^{-11}	9.6×10^{-12}	1.3×10^{-10}	1.8×10^{-10}	5.9×10^{-11}	3.4×10^{-10}	1.2×10^{-6}
Chromium III[b]	5.1×10^{-10}	3.6×10^{-10}	1.6×10^{-10}	7.6×10^{-11}	6.2×10^{-10}	1.4×10^{-10}	2.8×10^{-9}	1.5×10^{-9}	5.9×10^{-10}	9.7×10^{-9}	2.4×10^{-5}
Chromium VI[b]	5.6×10^{-11}	4.0×10^{-11}	1.8×10^{-11}	8.3×10^{-12}	6.8×10^{-11}	1.6×10^{-11}	3.1×10^{-10}	1.6×10^{-10}	6.6×10^{-11}	1.1×10^{-9}	2.7×10^{-6}
Cobalt	2.3×10^{-10}	1.6×10^{-10}	7.3×10^{-11}	3.4×10^{-11}	2.8×10^{-10}	6.4×10^{-11}	1.3×10^{-9}	6.0×10^{-10}	2.6×10^{-10}	4.3×10^{-9}	1.4×10^{-5}
Copper	6.6×10^{-10}	5.1×10^{-10}	2.0×10^{-10}	9.8×10^{-11}	7.9×10^{-10}	1.9×10^{-10}	3.4×10^{-9}	2.3×10^{-9}	8.5×10^{-10}	1.2×10^{-8}	2.1×10^{-5}
Lead	1.1×10^{-9}	1.2×10^{-9}	4.1×10^{-10}	1.9×10^{-10}	1.3×10^{-9}	3.1×10^{-10}	4.2×10^{-9}	3.7×10^{-9}	1.7×10^{-9}	1.2×10^{-8}	5.8×10^{-5}
Lithium	2.0×10^{-10}	1.3×10^{-10}	6.2×10^{-11}	2.9×10^{-11}	2.4×10^{-10}	5.5×10^{-11}	1.2×10^{-9}	5.1×10^{-10}	2.1×10^{-10}	4.0×10^{-9}	1.0×10^{-5}
Manganese	1.7×10^{-8}	1.4×10^{-8}	6.0×10^{-9}	2.7×10^{-9}	2.1×10^{-8}	4.9×10^{-9}	8.6×10^{-8}	4.4×10^{-8}	2.3×10^{-8}	2.9×10^{-7}	6.6×10^{-4}
Mercury	3.3×10^{-12}	3.9×10^{-12}	1.1×10^{-12}	5.2×10^{-13}	3.9×10^{-12}	1.1×10^{-12}	1.3×10^{-11}	2.0×10^{-11}	7.0×10^{-12}	3.5×10^{-11}	9.0×10^{-8}
Molybdenum	6.2×10^{-10}	5.2×10^{-10}	2.1×10^{-10}	9.3×10^{-11}	7.5×10^{-10}	1.9×10^{-10}	3.1×10^{-9}	2.1×10^{-9}	1.1×10^{-9}	1.0×10^{-8}	2.4×10^{-5}
Nickel	7.9×10^{-10}	5.9×10^{-10}	2.5×10^{-10}	1.2×10^{-10}	9.5×10^{-10}	2.3×10^{-10}	4.2×10^{-9}	2.4×10^{-9}	1.0×10^{-9}	1.4×10^{-8}	2.9×10^{-5}
Selenium	5.2×10^{-11}	5.3×10^{-11}	1.7×10^{-11}	8.0×10^{-12}	6.2×10^{-11}	1.6×10^{-11}	2.3×10^{-10}	2.6×10^{-10}	8.9×10^{-11}	7.2×10^{-10}	4.4×10^{-6}
Silver	2.3×10^{-11}	2.0×10^{-11}	7.3×10^{-12}	3.5×10^{-12}	2.9×10^{-11}	6.7×10^{-12}	1.3×10^{-10}	9.1×10^{-11}	3.0×10^{-11}	3.9×10^{-10}	1.0×10^{-6}
Thallium	1.8×10^{-11}	1.9×10^{-11}	6.7×10^{-12}	3.0×10^{-12}	2.1×10^{-11}	5.7×10^{-12}	7.4×10^{-11}	7.3×10^{-11}	3.3×10^{-11}	2.2×10^{-10}	3.6×10^{-6}
Uranium	3.7×10^{-9}	3.7×10^{-9}	1.4×10^{-9}	6.1×10^{-10}	4.4×10^{-9}	1.1×10^{-9}	1.6×10^{-8}	1.3×10^{-8}	6.1×10^{-9}	4.9×10^{-8}	1.2×10^{-4}
Vanadium	1.7×10^{-9}	1.7×10^{-9}	6.3×10^{-10}	2.7×10^{-10}	2.1×10^{-9}	6.0×10^{-10}	7.5×10^{-9}	6.9×10^{-9}	3.9×10^{-9}	2.4×10^{-8}	3.8×10^{-5}
Zinc	2.0×10^{-9}	1.3×10^{-9}	6.3×10^{-10}	2.8×10^{-10}	2.5×10^{-9}	5.5×10^{-10}	1.3×10^{-8}	4.9×10^{-9}	2.0×10^{-9}	4.0×10^{-8}	9.9×10^{-5}
Inorganic anions											
Fluoride	1.6×10^{-10}	1.1×10^{-10}	5.1×10^{-11}	2.4×10^{-11}	1.9×10^{-10}	4.4×10^{-11}	8.3×10^{-10}	4.0×10^{-10}	1.8×10^{-10}	2.8×10^{-9}	6.7×10^{-6}
Nitrate	9.1×10^{-9}	1.2×10^{-8}	3.9×10^{-9}	1.5×10^{-9}	1.1×10^{-8}	3.8×10^{-9}	2.8×10^{-8}	5.0×10^{-8}	3.2×10^{-8}	6.9×10^{-8}	1.2×10^{-4}
Nitrite	9.1×10^{-11}	1.1×10^{-10}	3.8×10^{-11}	1.5×10^{-11}	1.1×10^{-10}	3.7×10^{-11}	2.9×10^{-10}	4.8×10^{-10}	3.0×10^{-10}	7.4×10^{-10}	6.7×10^{-7}

TABLE F.8 (Cont.)

Contaminant	Estimated Concentration of Respirable Particulates in Air at Receptor Locations[a] (mg/m^3)										
	A	B	C	D	E	F	G	H	I	J	K
PAHs	6.9×10^{-8}	4.4×10^{-8}	2.0×10^{-8}	1.0×10^{-8}	8.4×10^{-8}	1.9×10^{-8}	3.7×10^{-7}	1.8×10^{-7}	7.0×10^{-8}	1.3×10^{-6}	1.3×10^{-6}
PCBs	2.1×10^{-10}	2.8×10^{-10}	8.8×10^{-11}	3.5×10^{-11}	2.5×10^{-10}	8.8×10^{-11}	6.4×10^{-10}	1.3×10^{-9}	7.2×10^{-15}	1.6×10^{-9}	7.2×10^{-7}
Nitroaromatic compounds											
DNB	4.4×10^{-11}	2.6×10^{-11}	1.3×10^{-11}	6.4×10^{-12}	5.4×10^{-11}	1.2×10^{-11}	2.6×10^{-10}	1.1×10^{-10}	3.8×10^{-11}	9.5×10^{-10}	1.6×10^{-7}
2,4-DNT	5.8×10^{-12}	8.7×10^{-12}	1.6×10^{-12}	9.5×10^{-13}	6.5×10^{-12}	1.9×10^{-12}	1.5×10^{-11}	5.4×10^{-11}	1.4×10^{-11}	2.9×10^{-11}	NA[c]
2,6-DNT	6.8×10^{-12}	1.0×10^{-11}	1.9×10^{-12}	1.1×10^{-12}	7.7×10^{-12}	2.2×10^{-12}	1.8×10^{-11}	6.4×10^{-11}	1.6×10^{-11}	3.4×10^{-11}	NA
NB	5.6×10^{-11}	8.4×10^{-11}	1.6×10^{-11}	9.2×10^{-12}	6.3×10^{-11}	1.8×10^{-11}	1.5×10^{-10}	5.2×10^{-10}	1.3×10^{-10}	2.8×10^{-10}	NA
TNB	1.0×10^{-10}	1.5×10^{-10}	2.8×10^{-11}	1.6×10^{-11}	1.1×10^{-10}	3.2×10^{-11}	2.6×10^{-10}	9.4×10^{-10}	2.4×10^{-10}	5.0×10^{-10}	NA
TNT	1.9×10^{-10}	2.8×10^{-10}	5.3×10^{-11}	3.1×10^{-11}	2.1×10^{-10}	6.0×10^{-11}	4.9×10^{-10}	1.7×10^{-9}	4.4×10^{-10}	9.3×10^{-10}	9.1×10^{-7}

[a] The potential receptors are described in Table F.1, and their locations are shown in Figure F.1. Except for receptor K, the airborne concentrations of chemicals were calculated from the estimated annual average respirable particulate concentrations originating from contaminated sources and the contaminant concentrations in those sources. For receptor K, the airborne concentrations of chemicals are based on a respirable particulate concentration of 1 mg/m^3 and the UL_{95} chemical concentrations in sitewide soil.

[b] The concentrations of chromium III and chromium VI were estimated assuming that these two contaminants represent 90% and 10%, respectively, of the total chromium concentration.

[c] NA means the entry is not applicable. (The worker is assumed to be wearing respiratory protective equipment when handling material at the TSA; this nitroaromatic compound has not been detected in other, sitewide soil that would be handled.)

TABLE F.9 Estimated Average Airborne Concentrations of Chemicals at Receptor Locations during the 7-Year Cleanup Period for Alternative 7a, Vitrification

	Estimated Concentration of Respirable Particulates in Air at Receptor Locations[a] (mg/m³)										
Contaminant	A	B	C	D	E	F	G	H	I	J	K
Metals											
Antimony	7.8×10^{-10}	5.3×10^{-10}	2.1×10^{-10}	1.0×10^{-10}	9.4×10^{-10}	1.9×10^{-10}	4.6×10^{-9}	2.1×10^{-9}	7.8×10^{-10}	2.1×10^{-8}	7.2×10^{-6}
Arsenic	5.3×10^{-10}	7.5×10^{-10}	1.9×10^{-10}	8.8×10^{-11}	6.3×10^{-10}	1.6×10^{-10}	2.2×10^{-9}	2.8×10^{-9}	1.2×10^{-9}	8.6×10^{-9}	1.9×10^{-5}
Barium	5.1×10^{-9}	4.7×10^{-9}	1.6×10^{-9}	7.3×10^{-10}	6.2×10^{-9}	1.4×10^{-9}	2.7×10^{-8}	1.5×10^{-8}	7.1×10^{-9}	1.2×10^{-7}	1.9×10^{-4}
Beryllium	2.3×10^{-11}	2.2×10^{-11}	6.9×10^{-12}	3.2×10^{-12}	2.8×10^{-11}	6.2×10^{-12}	1.2×10^{-10}	7.9×10^{-11}	3.4×10^{-11}	5.4×10^{-10}	1.0×10^{-6}
Cadmium	2.8×10^{-11}	3.8×10^{-11}	1.0×10^{-11}	5.5×10^{-12}	3.3×10^{-11}	8.1×10^{-12}	1.2×10^{-10}	2.1×10^{-10}	6.2×10^{-11}	4.2×10^{-10}	1.2×10^{-6}
Chromium III[b]	5.0×10^{-10}	4.3×10^{-10}	1.5×10^{-10}	7.0×10^{-11}	6.0×10^{-10}	1.3×10^{-10}	2.7×10^{-9}	1.6×10^{-9}	6.7×10^{-10}	1.2×10^{-8}	2.4×10^{-5}
Chromium VI[b]	5.5×10^{-11}	4.8×10^{-11}	1.7×10^{-11}	7.7×10^{-12}	6.6×10^{-11}	1.5×10^{-11}	3.0×10^{-10}	1.8×10^{-10}	7.4×10^{-11}	1.3×10^{-9}	2.7×10^{-6}
Cobalt	2.3×10^{-10}	2.0×10^{-10}	6.9×10^{-11}	3.1×10^{-11}	2.7×10^{-10}	6.0×10^{-11}	1.2×10^{-9}	6.6×10^{-10}	3.1×10^{-10}	5.3×10^{-9}	1.4×10^{-5}
Copper	6.4×10^{-10}	6.0×10^{-10}	1.9×10^{-10}	9.5×10^{-11}	7.6×10^{-10}	1.7×10^{-10}	3.3×10^{-9}	2.6×10^{-9}	9.4×10^{-10}	1.4×10^{-8}	2.1×10^{-5}
Lead	1.1×10^{-9}	1.5×10^{-9}	4.4×10^{-10}	2.1×10^{-10}	1.3×10^{-9}	3.2×10^{-10}	4.1×10^{-9}	4.4×10^{-9}	2.2×10^{-9}	1.4×10^{-8}	5.8×10^{-5}
Lithium	1.9×10^{-10}	1.5×10^{-10}	5.8×10^{-11}	2.6×10^{-11}	2.4×10^{-10}	5.1×10^{-11}	1.2×10^{-9}	5.6×10^{-10}	2.4×10^{-10}	4.9×10^{-9}	1.0×10^{-5}
Manganese	1.7×10^{-8}	1.8×10^{-8}	5.8×10^{-9}	2.6×10^{-9}	2.1×10^{-8}	4.8×10^{-9}	8.3×10^{-8}	5.0×10^{-8}	2.8×10^{-8}	3.5×10^{-7}	6.6×10^{-4}
Mercury	3.1×10^{-12}	4.5×10^{-12}	1.1×10^{-12}	6.1×10^{-13}	3.6×10^{-12}	9.4×10^{-13}	1.2×10^{-11}	2.3×10^{-11}	7.4×10^{-12}	4.2×10^{-11}	9.0×10^{-8}
Molybdenum	6.1×10^{-10}	7.2×10^{-10}	1.9×10^{-10}	9.0×10^{-11}	7.3×10^{-10}	1.7×10^{-10}	2.9×10^{-9}	2.4×10^{-9}	1.2×10^{-9}	1.2×10^{-8}	2.4×10^{-5}
Nickel	7.7×10^{-10}	7.2×10^{-10}	2.3×10^{-10}	1.1×10^{-10}	9.2×10^{-10}	2.1×10^{-10}	4.1×10^{-9}	2.7×10^{-9}	1.1×10^{-9}	1.8×10^{-8}	2.9×10^{-5}
Selenium	5.0×10^{-11}	5.9×10^{-11}	1.7×10^{-11}	8.8×10^{-12}	5.8×10^{-11}	1.4×10^{-11}	2.2×10^{-10}	3.0×10^{-10}	9.4×10^{-11}	8.8×10^{-10}	4.4×10^{-6}
Silver	2.3×10^{-11}	2.1×10^{-11}	7.4×10^{-12}	3.6×10^{-12}	2.7×10^{-11}	6.1×10^{-12}	1.3×10^{-10}	1.0×10^{-10}	3.3×10^{-11}	4.8×10^{-10}	1.0×10^{-6}
Thallium	1.8×10^{-11}	2.4×10^{-11}	6.7×10^{-12}	3.2×10^{-12}	2.1×10^{-11}	5.4×10^{-12}	7.0×10^{-11}	8.6×10^{-11}	3.8×10^{-11}	2.6×10^{-10}	3.6×10^{-6}
Uranium	3.8×10^{-9}	4.7×10^{-9}	1.4×10^{-9}	6.4×10^{-10}	4.4×10^{-9}	1.1×10^{-9}	1.5×10^{-8}	1.5×10^{-8}	7.3×10^{-9}	5.9×10^{-8}	1.2×10^{-4}
Vanadium	1.7×10^{-9}	2.5×10^{-9}	5.6×10^{-10}	2.6×10^{-10}	2.0×10^{-9}	5.1×10^{-10}	7.1×10^{-9}	8.1×10^{-9}	4.2×10^{-9}	2.8×10^{-8}	3.8×10^{-5}
Zinc	1.9×10^{-9}	1.5×10^{-9}	5.9×10^{-10}	2.5×10^{-10}	2.4×10^{-9}	5.0×10^{-10}	1.2×10^{-8}	5.3×10^{-9}	2.2×10^{-9}	4.9×10^{-8}	9.9×10^{-5}
Inorganic anions											
Fluoride	1.5×10^{-10}	1.4×10^{-10}	4.8×10^{-11}	2.2×10^{-11}	1.9×10^{-10}	4.1×10^{-11}	8.0×10^{-10}	4.4×10^{-10}	2.2×10^{-10}	3.5×10^{-9}	6.7×10^{-6}
Nitrate	8.7×10^{-9}	2.0×10^{-8}	3.3×10^{-9}	1.6×10^{-9}	1.0×10^{-8}	3.1×10^{-9}	2.5×10^{-8}	6.0×10^{-8}	3.4×10^{-8}	7.2×10^{-8}	1.2×10^{-4}
Nitrite	8.8×10^{-11}	1.9×10^{-10}	3.2×10^{-11}	1.6×10^{-11}	1.0×10^{-10}	3.1×10^{-11}	2.6×10^{-10}	5.8×10^{-10}	3.3×10^{-10}	8.0×10^{-10}	6.7×10^{-7}

TABLE F.9 (Cont.)

Contaminant	Estimated Concentration of Respirable Particulates in Air at Receptor Locations[a] (mg/m^3)										
	A	B	C	D	E	F	G	H	I	J	K
PAHs	6.9×10^{-9}	5.6×10^{-8}	1.8×10^{-8}	1.0×10^{-8}	8.1×10^{-8}	1.7×10^{-8}	3.6×10^{-7}	2.0×10^{-7}	8.0×10^{-8}	1.7×10^{-6}	1.3×10^{-6}
PCBs	2.0×10^{-10}	4.5×10^{-10}	7.7×10^{-11}	3.9×10^{-11}	2.4×10^{-10}	7.1×10^{-11}	5.7×10^{-10}	1.5×10^{-9}	7.7×10^{-10}	1.7×10^{-9}	7.2×10^{-7}
Nitroaromatic compounds											
DNB	4.3×10^{-11}	2.9×10^{-11}	1.2×10^{-11}	5.6×10^{-12}	5.2×10^{-11}	1.1×10^{-11}	2.5×10^{-10}	1.2×10^{-10}	4.4×10^{-11}	1.2×10^{-9}	1.6×10^{-7}
2,4-DNT	5.1×10^{-12}	8.5×10^{-12}	2.1×10^{-12}	1.4×10^{-12}	5.5×10^{-12}	1.5×10^{-12}	1.3×10^{-11}	6.5×10^{-11}	1.4×10^{-11}	3.6×10^{-11}	NA[c]
2,6-DNT	6.0×10^{-12}	1.0×10^{-11}	2.4×10^{-12}	1.6×10^{-12}	6.4×10^{-12}	1.8×10^{-12}	1.6×10^{-11}	7.6×10^{-11}	1.6×10^{-11}	4.2×10^{-11}	NA
NB	4.9×10^{-11}	8.2×10^{-11}	2.0×10^{-11}	1.3×10^{-11}	5.3×10^{-11}	1.4×10^{-11}	1.3×10^{-10}	6.2×10^{-10}	1.3×10^{-10}	3.5×10^{-10}	NA
TNB	8.8×10^{-11}	1.5×10^{-10}	3.6×10^{-11}	2.3×10^{-11}	9.5×10^{-11}	2.6×10^{-11}	2.3×10^{-10}	1.1×10^{-9}	2.4×10^{-10}	6.2×10^{-10}	NA
TNT	1.6×10^{-10}	2.7×10^{-10}	6.7×10^{-11}	4.4×10^{-11}	1.8×10^{-10}	4.8×10^{-11}	4.3×10^{-10}	2.1×10^{-9}	4.4×10^{-10}	1.2×10^{-9}	9.1×10^{-7}

[a] The potential receptors are described in Table F.1, and their locations are shown in Figure F.1. Except for receptor K, the airborne concentrations of chemicals were calculated from the estimated annual average respirable particulate concentrations originating from contaminated sources and the contaminant concentrations in those sources. For receptor K, the airborne concentrations of chemicals are based on a respirable particulate concentration of 1 mg/m^3 and the UL_{95} chemical concentrations in sitewide soil.

[b] The concentrations of chromium III and chromium VI were estimated assuming that these two contaminants represent 90% and 10%, respectively, of the total chromium concentration.

[c] NA means the entry is not applicable. (The worker is assumed to be wearing respiratory protective equipment when handling material at the TSA; this nitroaromatic compound has not been detected in other, sitewide soil that would be handled.)

TABLE F.10 Estimated Concentrations of Radionuclides in Soil at Receptor Locations for Alternative 6a, Chemical Stabilization/Solidification, and Alternative 7a, Vitrification

Alternative/ Contaminant	Estimated Concentration in Soil at Receptor Locations[a] (pCi/g)										
	A	B	C	D	E	F	G	H	I	J	K
Chemical Stabilization/Solidification											
Actinium-227	1.4×10^{-6}	1.4×10^{-6}	1.1×10^{-6}	4.7×10^{-6}	1.6×10^{-5}	9.5×10^{-6}	3.2×10^{-5}	5.9×10^{-5}	3.3×10^{-5}	1.0×10^{-4}	1.2
Lead-210	4.4×10^{-5}	4.7×10^{-5}	2.9×10^{-5}	1.3×10^{-5}	5.0×10^{-5}	2.5×10^{-5}	1.2×10^{-4}	1.9×10^{-4}	8.4×10^{-5}	3.1×10^{-4}	11
Protactinium-231	2.0×10^{-5}	1.9×10^{-5}	1.5×10^{-5}	6.4×10^{-6}	2.2×10^{-5}	1.3×10^{-5}	4.6×10^{-5}	8.0×10^{-5}	4.4×10^{-5}	1.5×10^{-4}	2.5
Radium-226	3.2×10^{-5}	3.4×10^{-5}	2.2×10^{-5}	9.8×10^{-6}	3.6×10^{-5}	1.9×10^{-5}	9.1×10^{-5}	1.3×10^{-4}	5.8×10^{-5}	2.7×10^{-4}	11
Radium-228	1.7×10^{-5}	1.9×10^{-5}	1.1×10^{-5}	5.1×10^{-6}	2.0×10^{-5}	9.8×10^{-6}	4.9×10^{-5}	7.0×10^{-5}	3.1×10^{-5}	1.4×10^{-4}	5.9
Thorium-230	5.8×10^{-4}	5.5×10^{-4}	4.7×10^{-4}	1.9×10^{-4}	6.4×10^{-4}	4.0×10^{-4}	1.2×10^{-3}	2.5×10^{-3}	1.4×10^{-3}	3.7×10^{-3}	5.2
Thorium-232	9.1×10^{-6}	1.1×10^{-5}	5.2×10^{-6}	2.7×10^{-6}	1.0×10^{-5}	4.5×10^{-6}	3.2×10^{-5}	3.0×10^{-5}	1.1×10^{-5}	1.0×10^{-4}	5.9
Uranium-235	5.9×10^{-6}	6.6×10^{-6}	3.5×10^{-6}	1.8×10^{-6}	6.7×10^{-6}	3.0×10^{-6}	2.0×10^{-5}	2.0×10^{-5}	7.4×10^{-6}	6.3×10^{-5}	3.0
Uranium-238	1.3×10^{-4}	1.4×10^{-4}	7.6×10^{-5}	3.9×10^{-5}	1.5×10^{-4}	6.5×10^{-5}	4.3×10^{-4}	4.3×10^{-4}	1.6×10^{-4}	1.4×10^{-3}	65
Vitrification											
Actinium-227	1.0×10^{-5}	1.9×10^{-5}	8.1×10^{-6}	4.1×10^{-6}	1.1×10^{-5}	7.4×10^{-6}	2.1×10^{-5}	7.7×10^{-5}	3.3×10^{-5}	5.8×10^{-5}	1.2
Lead-210	4.6×10^{-5}	6.3×10^{-5}	2.7×10^{-5}	1.7×10^{-5}	4.9×10^{-5}	2.4×10^{-5}	1.1×10^{-4}	3.2×10^{-4}	1.0×10^{-4}	3.3×10^{-4}	11
Protactinium-231	1.4×10^{-5}	2.6×10^{-5}	1.1×10^{-5}	5.7×10^{-6}	1.6×10^{-5}	1.0×10^{-5}	3.2×10^{-5}	1.1×10^{-4}	4.4×10^{-5}	9.5×10^{-5}	2.5
Radium-226	2.9×10^{-5}	4.5×10^{-5}	1.8×10^{-5}	1.1×10^{-5}	3.3×10^{-5}	1.7×10^{-5}	7.9×10^{-5}	1.9×10^{-4}	6.5×10^{-5}	2.7×10^{-4}	11
Radium-228	1.7×10^{-5}	2.5×10^{-5}	1.0×10^{-5}	6.1×10^{-6}	1.9×10^{-5}	9.1×10^{-6}	4.6×10^{-5}	1.1×10^{-4}	3.7×10^{-5}	1.5×10^{-4}	5.9
Thorium-230	4.1×10^{-4}	7.8×10^{-4}	3.4×10^{-4}	1.7×10^{-4}	4.5×10^{-4}	3.1×10^{-4}	7.4×10^{-4}	3.3×10^{-3}	1.4×10^{-3}	1.6×10^{-3}	5.2
Thorium-232	9.0×10^{-6}	1.3×10^{-5}	4.9×10^{-6}	3.0×10^{-6}	1.0×10^{-5}	4.3×10^{-6}	3.0×10^{-5}	4.8×10^{-5}	1.3×10^{-5}	1.2×10^{-4}	5.9
Uranium-235	5.4×10^{-6}	8.2×10^{-6}	3.1×10^{-6}	1.8×10^{-6}	6.1×10^{-6}	2.8×10^{-6}	1.8×10^{-5}	2.9×10^{-5}	8.6×10^{-6}	7.2×10^{-5}	3.0
Uranium-238	1.2×10^{-4}	1.8×10^{-4}	6.8×10^{-5}	4.0×10^{-5}	1.3×10^{-4}	6.0×10^{-5}	3.9×10^{-4}	6.3×10^{-4}	1.9×10^{-4}	1.6×10^{-3}	65

[a] The potential receptors are described in Table F.1, and their locations are shown in Figure F.1. Except for receptor K, concentrations were calculated from the estimated annual average total particulate concentrations originating from contaminated sources, the contaminant concentrations in those sources, and the estimated deposition on the ground surface. Values represent cumulative soil concentrations for the 7-year cleanup period. The UL_{95} concentrations in sitewide soil were used for receptor K.

TABLE F.11 Estimated Concentrations of Chemicals in Soil at Receptor Locations for Alternative 6a, Chemical Stabilization/ Solidification

Contaminant	Estimated Concentration in Soil at Receptor Locations[a] (mg/kg)										
	A	B	C	D	E	F	G	H	I	J	K
Metals											
Antimony	8.9×10^{-5}	8.4×10^{-5}	4.3×10^{-5}	2.5×10^{-5}	1.1×10^{-4}	4.1×10^{-5}	4.1×10^{-4}	2.9×10^{-4}	7.5×10^{-5}	1.5×10^{-3}	7.2
Arsenic	6.4×10^{-5}	6.3×10^{-5}	4.2×10^{-5}	2.0×10^{-5}	7.2×10^{-3}	3.6×10^{-5}	2.0×10^{-4}	2.4×10^{-4}	9.8×10^{-5}	6.5×10^{-4}	1.9×10^{1}
Barium	5.9×10^{-4}	5.9×10^{-4}	3.2×10^{-4}	1.7×10^{-4}	6.8×10^{-4}	2.9×10^{-4}	2.4×10^{-3}	1.8×10^{-3}	5.5×10^{-4}	8.4×10^{-3}	1.9×10^{2}
Beryllium	2.7×10^{-6}	2.6×10^{-6}	1.5×10^{-6}	8.0×10^{-7}	3.2×10^{-6}	1.4×10^{-6}	1.1×10^{-5}	9.4×10^{-6}	3.0×10^{-6}	4.0×10^{-5}	1.0
Cadmium	2.9×10^{-6}	3.0×10^{-6}	1.8×10^{-6}	8.2×10^{-7}	3.3×10^{-6}	1.6×10^{-6}	1.0×10^{-5}	1.2×10^{-5}	4.8×10^{-6}	2.8×10^{-5}	1.2
Chromium III[b]	5.7×10^{-5}	5.6×10^{-5}	3.1×10^{-5}	1.7×10^{-5}	6.7×10^{-5}	2.8×10^{-5}	2.4×10^{-4}	1.9×10^{-4}	5.6×10^{-5}	8.6×10^{-4}	2.4×10^{1}
Chromium VI[b]	6.3×10^{-6}	6.2×10^{-6}	3.4×10^{-6}	1.8×10^{-6}	7.5×10^{-6}	3.1×10^{-6}	2.7×10^{-5}	2.1×10^{-5}	6.2×10^{-6}	9.5×10^{-5}	2.7
Cobalt	2.6×10^{-5}	2.6×10^{-5}	1.4×10^{-5}	7.7×10^{-6}	3.1×10^{-5}	1.3×10^{-5}	1.1×10^{-4}	8.5×10^{-5}	2.5×10^{-5}	3.9×10^{-4}	1.4×10^{1}
Copper	7.2×10^{-5}	7.0×10^{-5}	3.9×10^{-5}	2.1×10^{-5}	8.4×10^{-5}	3.6×10^{-5}	2.9×10^{-4}	2.5×10^{-4}	8.0×10^{-5}	1.0×10^{-3}	2.1×10^{1}
Lead	1.1×10^{-4}	1.3×10^{-4}	7.1×10^{-5}	3.5×10^{-5}	1.2×10^{-4}	5.4×10^{-5}	3.4×10^{-4}	3.2×10^{-4}	1.2×10^{-4}	9.9×10^{-4}	5.8×10^{1}
Lithium	2.2×10^{-5}	2.2×10^{-5}	1.2×10^{-5}	6.4×10^{-6}	2.7×10^{-5}	1.1×10^{-5}	1.0×10^{-4}	7.4×10^{-5}	2.2×10^{-5}	3.5×10^{-4}	1.0×10^{1}
Manganese	2.0×10^{-3}	2.0×10^{-3}	1.2×10^{-3}	6.1×10^{-4}	2.3×10^{-3}	9.9×10^{-4}	7.4×10^{-3}	6.1×10^{-3}	1.9×10^{-3}	2.5×10^{-2}	6.6×10^{2}
Mercury	3.2×10^{-7}	3.4×10^{-7}	2.1×10^{-7}	9.9×10^{-8}	3.7×10^{-7}	1.9×10^{-7}	9.8×10^{-7}	1.4×10^{-4}	5.6×10^{-7}	2.9×10^{-6}	9.0×10^{-2}
Molybdenum	7.3×10^{-5}	7.1×10^{-5}	4.5×10^{-5}	2.2×10^{-5}	8.5×10^{-5}	4.0×10^{-5}	2.7×10^{-4}	2.6×10^{-4}	1.0×10^{-4}	9.4×10^{-4}	2.4×10^{1}
Nickel	8.8×10^{-5}	8.6×10^{-5}	4.9×10^{-5}	2.6×10^{-5}	1.0×10^{-4}	4.5×10^{-5}	3.6×10^{-4}	3.0×10^{-4}	9.8×10^{-5}	1.3×10^{-3}	2.9×10^{1}
Selenium	5.1×10^{-6}	5.4×10^{-6}	3.0×10^{-6}	1.6×10^{-6}	$6.0\ 10^{-6}$	2.8×10^{-6}	1.8×10^{-5}	2.1×10^{-5}	7.4×10^{-6}	6.2×10^{-5}	4.4
Silver	2.4×10^{-6}	2.5×10^{-6}	1.3×10^{-6}	6.8×10^{-7}	2.8×10^{-6}	1.2×10^{-6}	1.1×10^{-5}	8.5×10^{-6}	2.7×10^{-6}	3.3×10^{-5}	1.0
Thallium	2.0×10^{-6}	2.1×10^{-6}	1.3×10^{-6}	6.3×10^{-7}	2.2×10^{-6}	1.1×10^{-6}	6.1×10^{-6}	6.9×10^{-6}	2.6×10^{-6}	1.9×10^{-5}	3.6
Uranium	4.0×10^{-4}	4.4×10^{-4}	2.5×10^{-4}	1.3×10^{-4}	4.5×10^{-4}	2.1×10^{-4}	1.3×10^{-3}	1.3×10^{-3}	4.9×10^{-4}	4.3×10^{-3}	1.2×10^{2}
Vanadium	2.1×10^{-4}	2.0×10^{-4}	1.5×10^{-4}	6.7×10^{-5}	2.4×10^{-4}	1.3×10^{-4}	6.6×10^{-4}	8.1×10^{-4}	3.8×10^{-4}	2.3×10^{-3}	3.8×10^{1}
Zinc	2.2×10^{-4}	2.3×10^{-4}	1.1×10^{-4}	6.2×10^{-5}	2.6×10^{-4}	1.1×10^{-4}	1.1×10^{-3}	7.2×10^{-4}	2.0×10^{-4}	3.5×10^{-3}	9.9×10^{1}
Inorganic anions											
Fluoride	1.8×10^{-5}	1.8×10^{-5}	9.7×10^{-6}	5.2×10^{-6}	2.1×10^{-5}	8.7×10^{-6}	7.1×10^{-5}	5.6×10^{-5}	1.7×10^{-5}	2.5×10^{-4}	6.7
Nitrate	1.2×10^{-3}	1.2×10^{-3}	1.0×10^{-3}	4.1×10^{-4}	1.4×10^{-3}	8.7×10^{-4}	2.5×10^{-3}	5.3×10^{-3}	3.1×10^{-3}	7.7×10^{-3}	1.2×10^{2}
Nitrite	1.2×10^{-5}	1.2×10^{-5}	9.8×10^{-6}	4.0×10^{-6}	1.3×10^{-5}	8.4×10^{-6}	2.5×10^{-5}	5.2×10^{-5}	3.0×10^{-5}	8.2×10^{-5}	6.7×10^{-1}

TABLE F.11 (Cont.)

Contaminant	Estimated Concentration in Soil at Receptor Locations[a] (mg/kg)										
	A	B	C	D	E	F	G	H	I	J	K
PAHs	7.1×10^{-9}	6.8×10^{-9}	3.7×10^{-9}	1.9×10^{-9}	8.5×10^{-9}	3.4×10^{-9}	3.2×10^{-8}	2.5×10^{-6}	9.1×10^{-9}	1.2×10^{-7}	1.3
PCBs	2.8×10^{-5}	2.6×10^{-5}	2.2×10^{-5}	9.0×10^{-6}	3.0×10^{-5}	1.9×10^{-5}	5.5×10^{-5}	1.2×10^{-4}	6.9×10^{-5}	1.7×10^{-4}	7.2×10^{-1}
Nitroaromatic compounds											
DNB	5.0×10^{-6}	4.6×10^{-6}	2.4×10^{-6}	1.4×10^{-6}	6.0×10^{-6}	2.3×10^{-6}	2.2×10^{-5}	1.6×10^{-5}	4.2×10^{-6}	8.5×10^{-5}	1.6×10^{-1}
2,4-DNT	4.2×10^{-7}	4.5×10^{-7}	2.7×10^{-7}	1.0×10^{-7}	4.6×10^{-7}	2.3×10^{-7}	9.2×10^{-7}	2.1×10^{-6}	9.3×10^{-7}	1.4×10^{-6}	-[c]
2,6-DNT	4.9×10^{-7}	5.2×10^{-7}	3.1×10^{-7}	1.2×10^{-7}	5.5×10^{-7}	2.7×10^{-7}	1.1×10^{-6}	2.5×10^{-6}	1.1×10^{-6}	1.6×10^{-6}	-
NB	4.0×10^{-6}	4.3×10^{-6}	2.6×10^{-6}	9.6×10^{-7}	4.5×10^{-6}	2.2×10^{-6}	8.8×10^{-6}	2.1×10^{-5}	9.0×10^{-6}	1.3×10^{-5}	-
TNB	7.2×10^{-6}	7.7×10^{-6}	4.6×10^{-6}	1.7×10^{-6}	8.0×10^{-6}	4.0×10^{-6}	1.6×10^{-5}	3.7×10^{-5}	1.6×10^{-5}	2.4×10^{-5}	-
TNT	1.3×10^{-5}	1.4×10^{-5}	8.5×10^{-6}	3.2×10^{-6}	1.5×10^{-5}	7.4×10^{-6}	2.9×10^{-5}	6.9×10^{-5}	3.0×10^{-5}	4.5×10^{-5}	9.1×10^{-1}

[a] The potential receptors are described in Table F.1, and their locations are shown in Figure F.1. Except for receptor K, concentrations were calculated from the estimated annual average total particulate concentrations originating from contaminated sources, the contaminant concentrations in those sources, and the estimated deposition on the ground surface. Values represent cumulative soil concentrations for the 7-year cleanup period. The UL_{95} concentrations in sitewide soil were used for receptor K.

[b] The concentrations of chromium III and chromium VI were estimated assuming that these two contaminants represent 90% and 10%, respectively, of the total chromium concentration.

[c] A hyphen indicates that the entry is not applicable.

TABLE F.12 Estimated Concentrations of Chemicals in Soil at Receptor Locations for Alternative 7a, Vitrification

Contaminant	Estimated Concentration in Soil at Receptor Locations[a] (mg/kg)										
	A	B	C	D	E	F	G	H	I	J	K
Metals											
Antimony	8.0×10^{-5}	1.0×10^{-4}	3.9×10^{-5}	2.4×10^{-5}	9.5×10^{-5}	3.8×10^{-5}	3.7×10^{-4}	4.0×10^{-4}	8.4×10^{-5}	1.9×10^{-3}	7.2
Arsenic	5.9×10^{-5}	9.2×10^{-5}	3.8×10^{-5}	2.1×10^{-5}	6.7×10^{-5}	3.4×10^{-5}	1.8×10^{-4}	3.8×10^{-4}	1.3×10^{-4}	7.7×10^{-4}	1.9×10^{1}
Barium	5.4×10^{-4}	7.6×10^{-4}	2.9×10^{-4}	1.7×10^{-4}	6.3×10^{-4}	2.7×10^{-4}	2.1×10^{-3}	2.7×10^{-3}	6.8×10^{-4}	1.0×10^{-2}	1.9×10^{2}
Beryllium	2.5×10^{-6}	3.4×10^{-6}	1.3×10^{-6}	7.9×10^{-7}	2.9×10^{-6}	1.3×10^{-6}	1.0×10^{-5}	1.4×10^{-5}	3.8×10^{-6}	4.8×10^{-5}	1.0
Cadmium	3.1×10^{-6}	4.2×10^{-6}	1.7×10^{-6}	1.1×10^{-6}	3.5×10^{-6}	1.6×10^{-6}	1.0×10^{-5}	2.1×10^{-5}	6.7×10^{-6}	3.6×10^{-5}	1.2
Chromium III[b]	5.2×10^{-5}	7.2×10^{-5}	2.8×10^{-5}	1.7×10^{-5}	6.2×10^{-5}	2.6×10^{-5}	2.2×10^{-4}	2.8×10^{-4}	6.9×10^{-5}	1.1×10^{-3}	2.4×10^{1}
Chromium VI[b]	5.8×10^{-6}	7.9×10^{-6}	3.1×10^{-6}	1.8×10^{-6}	6.8×10^{-6}	2.9×10^{-6}	2.4×10^{-5}	3.1×10^{-5}	7.7×10^{-6}	1.2×10^{-4}	2.7
Cobalt	2.4×10^{-5}	3.3×10^{-5}	1.3×10^{-5}	7.6×10^{-6}	2.8×10^{-5}	1.2×10^{-5}	9.9×10^{-5}	1.2×10^{-4}	3.1×10^{-5}	4.7×10^{-4}	1.4×10^{1}
Copper	6.7×10^{-5}	9.0×10^{-5}	3.6×10^{-5}	2.2×10^{-5}	7.8×10^{-5}	3.4×10^{-5}	2.7×10^{-4}	3.8×10^{-4}	1.0×10^{-4}	1.3×10^{-3}	2.1×10^{1}
Lead	1.2×10^{-4}	1.8×10^{-4}	7.1×10^{-5}	4.0×10^{-5}	1.3×10^{-4}	5.7×10^{-5}	3.4×10^{-4}	5.7×10^{-4}	1.7×10^{-4}	1.2×10^{-3}	5.8×10^{1}
Lithium	2.0×10^{-5}	2.8×10^{-5}	1.1×10^{-5}	6.3×10^{-6}	2.4×10^{-5}	1.0×10^{-5}	9.5×10^{-5}	1.1×10^{-4}	2.6×10^{-5}	4.3×10^{-4}	1.0×10^{1}
Manganese	1.8×10^{-3}	2.7×10^{-3}	1.1×10^{-3}	6.0×10^{-4}	2.1×10^{-3}	9.4×10^{-4}	6.7×10^{-3}	9.3×10^{-3}	2.5×10^{-3}	3.1×10^{-2}	6.6×10^{2}
Mercury	3.4×10^{-7}	4.8×10^{-7}	2.0×10^{-7}	1.3×10^{-7}	3.8×10^{-7}	1.9×10^{-7}	9.7×10^{-7}	2.4×10^{-6}	7.8×10^{-7}	3.6×10^{-6}	9.0×10^{-2}
Molybdenum	6.5×10^{-5}	9.9×10^{-5}	3.9×10^{-5}	2.2×10^{-5}	7.6×10^{-5}	3.6×10^{-5}	2.4×10^{-4}	3.9×10^{-4}	1.3×10^{-4}	1.1×10^{-3}	2.4×10^{1}
Nickel	8.1×10^{-5}	1.1×10^{-4}	4.4×10^{-5}	2.6×10^{-5}	9.5×10^{-5}	4.1×10^{-5}	3.3×10^{-4}	4.5×10^{-4}	1.2×10^{-4}	1.6×10^{-3}	2.9×10^{1}
Selenium	5.2×10^{-6}	7.1×10^{-6}	2.9×10^{-6}	1.9×10^{-6}	5.9×10^{-6}	2.7×10^{-6}	1.8×10^{-5}	3.4×10^{-5}	9.8×10^{-6}	7.7×10^{-5}	4.4
Silver	2.4×10^{-6}	3.2×10^{-6}	1.2×10^{-6}	7.6×10^{-7}	2.7×10^{-6}	1.1×10^{-6}	1.0×10^{-5}	1.3×10^{-5}	3.4×10^{-6}	4.2×10^{-5}	1.0
Thallium	1.9×10^{-6}	3.0×10^{-6}	1.2×10^{-6}	7.0×10^{-7}	2.1×10^{-6}	1.0×10^{-6}	5.8×10^{-6}	1.1×10^{-5}	3.6×10^{-6}	2.3×10^{-5}	3.6
Uranium	3.9×10^{-4}	6.0×10^{-4}	2.4×10^{-4}	1.4×10^{-4}	4.4×10^{-4}	2.1×10^{-4}	1.3×10^{-3}	2.1×10^{-3}	6.6×10^{-4}	5.2×10^{-3}	1.2×10^{2}
Vanadium	1.9×10^{-4}	3.1×10^{-4}	1.3×10^{-4}	6.7×10^{-5}	2.1×10^{-4}	1.1×10^{-4}	5.8×10^{-4}	1.2×10^{-3}	5.0×10^{-4}	2.6×10^{-3}	3.8×10^{1}
Zinc	2.0×10^{-4}	2.8×10^{-4}	1.0×10^{-4}	6.1×10^{-5}	2.4×10^{-4}	9.7×10^{-5}	1.0×10^{-3}	1.0×10^{-3}	2.4×10^{-4}	4.3×10^{-3}	9.9×10^{1}
Inorganic anions											
Fluoride	1.6×10^{-5}	2.3×10^{-5}	8.9×10^{-6}	5.2×10^{-6}	1.9×10^{-5}	8.1×10^{-6}	6.4×10^{-5}	8.3×10^{-5}	2.1×10^{-5}	3.1×10^{-4}	6.7
Nitrate	1.0×10^{-3}	2.0×10^{-3}	8.5×10^{-4}	4.2×10^{-4}	1.2×10^{-3}	7.6×10^{-4}	2.1×10^{-3}	8.4×10^{-3}	4.2×10^{-3}	7.9×10^{-3}	1.2×10^{2}
Nitrite	1.0×10^{-5}	1.9×10^{-5}	8.2×10^{-6}	4.1×10^{-6}	1.2×10^{-5}	7.4×10^{-6}	2.2×10^{-5}	8.1×10^{-5}	4.1×10^{-5}	8.7×10^{-5}	6.7×10^{-1}

TABLE F.12 (Cont.)

Contaminant	Estimated Concentration in Soil at Receptor Locations[a] (mg/kg)										
	A	B	C	D	E	F	G	H	I	J	K
PAHs	6.6×10^{-9}	8.5×10^{-9}	3.2×10^{-9}	1.9×10^{-9}	7.8×10^{-9}	3.0×10^{-9}	2.9×10^{-8}	3.4×10^{-8}	1.0×10^{-8}	1.6×10^{-7}	1.3
PCBs	2.4×10^{-5}	4.4×10^{-5}	1.9×10^{-5}	9.6×10^{-6}	2.7×10^{-5}	1.7×10^{-3}	4.9×10^{-5}	1.9×10^{-4}	9.5×10^{-5}	1.8×10^{-4}	7.2×10^{-1}
Nitroaromatic compounds											
DNB	4.5×10^{-6}	5.7×10^{-6}	2.2×10^{-6}	1.3×10^{-6}	5.4×10^{-6}	2.1×10^{-6}	2.0×10^{-5}	2.3×10^{-5}	4.7×10^{-6}	1.0×10^{-4}	1.6×10^{-1}
2,4-DNT	5.9×10^{-7}	6.5×10^{-7}	3.0×10^{-7}	2.1×10^{-7}	6.1×10^{-7}	2.6×10^{-7}	1.2×10^{-6}	4.7×10^{-6}	1.4×10^{-6}	2.5×10^{-6}	-[c]
2,6-DNT	6.9×10^{-7}	7.6×10^{-7}	3.5×10^{-7}	2.5×10^{-7}	7.2×10^{-7}	3.1×10^{-7}	1.4×10^{-6}	5.5×10^{-6}	1.7×10^{-6}	2.9×10^{-6}	-
NB	5.7×10^{-6}	6.3×10^{-6}	2.9×10^{-6}	2.0×10^{-6}	5.9×10^{-6}	2.5×10^{-6}	1.1×10^{-5}	4.5×10^{-5}	1.4×10^{-5}	2.4×10^{-5}	-
TNB	1.0×10^{-5}	1.1×10^{-5}	5.2×10^{-6}	3.7×10^{-6}	1.1×10^{-5}	4.6×10^{-6}	2.1×10^{-5}	8.1×10^{-5}	2.5×10^{-5}	4.3×10^{-5}	-
TNT	1.9×10^{-5}	2.1×10^{-5}	9.7×10^{-6}	6.8×10^{-6}	2.0×10^{-5}	8.5×10^{-6}	3.8×10^{-5}	1.5×10^{-4}	4.6×10^{-5}	7.9×10^{-5}	9.1×10^{-1}

[a] The potential receptors are described in Table F.1, and their locations are shown in Figure F.1. Except for receptor K, concentrations were calculated from the estimated annual average total particulate concentrations originating from contaminated sources, the contaminant concentrations in those sources, and the estimated deposition on the ground surface. Values represent cumulative soil concentrations for the 7-year cleanup period. The UL_{95} concentrations in sitewide soil were used for receptor K.

[b] The concentrations of chromium III and chromium VI were estimated assuming that these two contaminants represent 90% and 10%, respectively, of the total chromium concentration.

[c] A hyphen indicates that the entry is not applicable.

TABLE F.13 Occupational Standards and Guidelines for Chemical Contaminants

Contaminant	Occupational Standard/Guideline[a] (mg/m³, except as noted) OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Comments
Metals				
Antimony	0.5	0.5	0.5	Antimony and compounds, as antimony.
Arsenic	0.01	0.2	0.002[e]	PEL: inorganic compounds, as arsenic. TLV: arsenic and soluble compounds, as arsenic. REL: 15-minute ceiling.
Barium	0.5	0.5	0.5	Soluble compounds, as barium.
Beryllium	0.002	0.002	0.0005[e]	PEL and TLV: beryllium and compounds, as beryllium. REL: not to exceed 0.0005 mg/m³.
Cadmium	0.005	0.05	-[e]	PEL: all cadmium compounds, including dust and fumes. TLV: cadmium dusts and salts, as cadmium.
Chromium III	0.5	0.5	0.5	Chromium III compounds, as chromium.
Chromium VI	NA	0.05	0.001[e]	TLV: water-soluble and certain water-insoluble chromium VI compounds, as chromium. REL: for carcinogenic compounds; for noncarcinogenic compounds, the REL is 0.025 mg/m³, with a 15-minute ceiling of 0.050 mg/m³.
Cobalt	0.1	0.05	0.5	Cobalt metal, fume, and dust, as cobalt.
Copper	1	1	1	Dusts and mists, as copper. PEL and REL for copper fume is 0.1; TLV for copper fume is 0.2 mg/m³.
Lead	0.05	0.15	<0.1	PEL: inorganic compounds, as lead. TLV: inorganic dusts and fumes, as lead.
Lithium	0.025	0.025	0.025	Lithium as lithium hydride.
Manganese	1	5	5	PEL and REL: fume, as manganese. TLV: dust and compounds; TLV for fume is 1 mg/m³.
Mercury	0.05	0.1	0.05	PEL and REL: mercury vapor, as mercury. TLV: aryl and inorganic compounds, as mercury.
Molybdenum	5	5	NA	PEL: soluble compounds, as molybdenum; PEL for insoluble compounds is 10 mg/m³ for total dust and 5 mg/m³ for the respirable fraction. TLV: soluble compounds, as molybdenum; TLV for insoluble compounds is 10 mg/m³.
Nickel	0.1	0.1	0.015[e]	PEL: soluble compounds, as nickel; PEL for metallic nickel and insoluble compounds is 1 mg/m³, as nickel. TLV: soluble compounds as nickel; TLV for insoluble compounds is 1 mg/m³.

TABLE F.13 (Cont.)

Contaminant	Occupational Standard/Guideline[a] (mg/m³, except as noted) OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Comments
Metals (cont.)				
Selenium	0.2	0.2	0.2	Selenium compounds, as selenium.
Silver	0.01	0.01	0.01	PEL and REL: metal, dust, and fume, as silver. TLV: soluble compounds, as silver; TLV for silver metal is 0.1 mg/m³.
Thallium	0.1	0.1	0.1	Soluble compounds, as thallium. Skin designation: refers to a potential contribution of the overall exposure by the cutaneous route, including mucous membranes and eyes — through airborne contact, or more particularly, through direct contact.
Uranium	0.05	0.2	0.05	PEL and REL: soluble compounds, as uranium; PEL and REL for insoluble compounds is 0.2 mg/m³, as uranium. TLV: soluble and insoluble compounds, as uranium.
Vanadium	0.05	0.05	0.05[e]	PEL: respirable dust, as vanadium oxide (V_2O_5). TLV: respirable dust and fume.
Zinc	5	10	5	REL and PEL: zinc oxide fume; 15-minute ceiling is 10 mg/m³. TLV: zinc oxide dust; TLV for fume is 5 mg/m³.
Inorganic anions				
Fluoride	2.5	2.5	2.5	Fluorides, as fluorine; TLV for fluorine is 1.6 mg/m³.
Nitrate	NA	NA	NA	
Nitrite	NA	NA	NA	
PAHs[f]	0.2	0.2	0.1[e]	PEL and TLV: for coal tar pitch volatiles, measured as the benzene-soluble fraction of total particulate matter. REL for coal tar pitch volatiles, measured as the cyclohexane-soluble fraction of total particulate matter.
PCBs[g]	0.5	0.5	0.001	PEL and TLV: for chlorodiphenyl (54% chlorine), skin designation; refers to a potential contribution of the overall exposure by the cutaneous route, including mucous membranes and eyes — through airborne contact, or more particularly, through direct contact.

TABLE F.13 (Cont.)

Contaminant	Occupational Standard/Guideline[a] (mg/m³, except as noted) OSHA PEL[b]	ACGIH TLV[c]	NIOSH REL[d]	Comments
Nitroaromatic compounds				
DNB	1	1	1	For all DNB isomers. Skin designation; refers to a potential contribution of the overall exposure by the cutaneous route, including mucous membranes and eyes — through airborne contact, or more particularly, through direct contact.
2,4-DNT	1.5	1.5	1.5[e]	For total DNT; isomer unspecified. Skin designation; refers to a potential contribution of the overall exposure by the cutaneous route, including mucous membranes and eyes — through airborne contact, or more particularly, through direct contact.
2,6-DNT	1.5	NA	1.5[e]	For total DNT; isomer unspecified. Skin designation; refers to a potential contribution of the overall exposure by the cutaneous route, including mucous membranes and eyes — through airborne contact, or more particularly, through direct contact.
NB	5	5	5	Skin designation; refers to a potential contribution of the overall exposure by the cutaneous route, including mucous membranes and eyes — through airborne contact, or more particularly, through direct contact.
TNB	0.5	NA	NA	Skin designation; refers to a potential contribution of the overall exposure by the cutaneous route, including mucous membranes and eyes — through airborne contact, or more particularly, through direct contact.
TNT	0.5	0.5	0.5	Skin designation; refers to a potential contribution of the overall exposure by the cutaneous route, including mucous membranes and eyes — through airborne contact, or more particularly, through direct contact.

[a] Each comment applies to the PEL, TLV, or REL, as specified; where no specific designation is noted, the comment applies to all three standards/guidelines; NA means no data available.

[b] OSHA permissible exposure limit (PEL) (29 CFR Part 1910); PELs are 8-hour time-weighted average (TWA) concentrations. The PEL listed for cadmium was recently finalized, and the standard takes effect December 14, 1992.

[c] ACGIH (1990) threshold limit values (TLVs); TLVs are 8-hour TWA concentrations.

[d] Recommended exposure limit (REL) of NIOSH (1990). Unless otherwise noted, RELs are the 10-hour TWA concentrations.

[e] Carcinogen; reduce exposure to lowest feasible level.

[f] Benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene.

[g] Arodor 1248, 1254, and 1260.

TABLE F.14 Estimated Annual Radiological Doses to Members of the General Public from Inhalation of Contaminants Released from the Site[a]

	Alternative 6a		Alternative 7a	
Receptor[b]	Dose from Airborne Particulates (mrem/yr)	Dose from Radon-222 Decay Products (WLM/yr)	Dose from Airborne Particulates (mrem/yr)	Dose from Radon-222 Decay Products (WLM/yr)
A	1.6×10^{-2}	7.8×10^{-5}	1.2×10^{-2}	1.1×10^{-4}
B	2.0×10^{-2}	1.8×10^{-4}	2.5×10^{-2}	2.5×10^{-4}
C	6.6×10^{-3}	3.9×10^{-5}	5.1×10^{-3}	5.6×10^{-5}
D	2.7×10^{-3}	2.5×10^{-5}	2.2×10^{-3}	3.6×10^{-5}
E	5.3×10^{-3}	2.3×10^{-5}	4.1×10^{-3}	3.3×10^{-5}
F	7.0×10^{-4}	3.4×10^{-6}	5.0×10^{-4}	5.0×10^{-6}
G	3.2×10^{-2}	1.1×10^{-4}	2.3×10^{-2}	1.5×10^{-4}
H	4.8×10^{-2}	1.5×10^{-4}	4.7×10^{-2}	2.2×10^{-4}
I	2.8×10^{-2}	9.7×10^{-5}	2.5×10^{-2}	1.4×10^{-4}
J	4.1×10^{-2}	1.8×10^{-4}	3.2×10^{-2}	2.7×10^{-4}

[a] The doses given in this table are averaged over the 7-year cleanup period. The estimated dose in any given year could be higher or lower, depending on the schedule of remedial action activities. Compared with these average values, the inhalation dose in the maximum year is predicted to be less than two times higher for radon-222 decay products and about four times higher for contaminated particulates. The total dose to these receptors can be obtained by multiplying the annual doses by the exposure duration given in Table F.2.

[b] The individual receptors are described in Table F.1, and their locations are shown in Figure F.1. Receptor J is included in this table because the principal means of exposure to on-site office workers is the same as that for off-site members of the general public, i.e., via inhalation of airborne contaminants.

TABLE F.15 Remedial Action Worker Requirements for the Final Alternatives

Activity	Worker Requirements[a] (person-years)			
	Alternative 6a	Alternative 7a	Alternative 7b	Alternative 7c
Excavation and on-site handling[b]	210	210	210	210
Volume reduction	18	18	18	18
Chemical stabilization	43	NA[c]	NA	NA
Vitrification	NA	250	250	250
Water treatment	29	29	29	29
Transportation of supplies and fill material[d]	85	61	27	27
Off-site transportation of contaminated material[d]	NA	NA	320	320
Disposal	170	210	210[e]	210[e]
Total	560	780	1,100	1,100

[a] Except for transportation, worker requirements are based on 250 work days per year, with 6.5 productive work hours per 8-hour shift (MK-Ferguson Company and Jacobs Engineering Group 1992). Estimates are reported to two significant figures.

[b] Includes worker requirements associated with remediating vicinity properties and contaminated sediment in the Busch Wildlife Area lakes, as well as reclaiming all excavated areas. Also includes the requirements associated with transporting process chemicals to a licensed facility for incineration.

[c] NA indicates that the entry is not applicable.

[d] See Section F.7 for additional information on transportation requirements.

[e] For this analysis, the worker requirements for off-site disposal are assumed to be the same as those for on-site disposal (Alternative 7a).

TABLE F.16 Radiological Doses and Health Risks to an On-Site Remedial Action Worker[a]

Exposure Route	Annual Dose (rem/yr)	Annual Risk[b]
External gamma irradiation	0.10	6×10^{-5}
Inhalation		
Particulates	0.22	1×10^{-4}
Radon-222 decay products	0.025[c]	9×10^{-6}
Incidental ingestion of soil	0.016	1×10^{-5}
Total[d]	0.36	2×10^{-4}

[a] The occupational doses associated with off-site disposal activities at the Envirocare facility (Alternative 7b) or the Hanford facility (Alternative 7c) are expected to be similar to those for on-site disposal activities at the Weldon Spring site (Alternative 7a).

[b] Based on a risk factor of 6×10^{-7}/mrem for all exposure pathways except inhalation of radon-222 and its short-lived decay products (EPA 1989b); a risk factor of 3.5×10^{-4}/WLM was used for inhalation of radon-222 decay products (National Research Council 1988). These two risk factors are discussed in greater detail in Section 4.1 of the BA (DOE 1992a).

[c] Annual dose in WLM/yr.

[d] To obtain the total annual dose (in mrem), the radon dose (in WLM) was converted to mrem with the factor of 1,000 mrem/WLM given in Publication 32 of the ICRP (1981). The estimated radiological risk to a remedial action worker at the site for the entire 7-year cleanup period would be about 1×10^{-3}.

TABLE F.17 Estimated Radiological Risks to Potential Receptors for Alternative 6a, Chemical Stabilization/Solidification, and Alternative 7a, Vitrification

Alternative/ Receptor	Inhalation of Contaminated Airborne Particulates[a]	Inhalation of Radon-222 Decay Products[b]	Total
Chemical Stabilization/ Solidification			
A	7×10^{-8}	2×10^{-7}	3×10^{-7}
B	8×10^{-8}	4×10^{-7}	5×10^{-7}
C	3×10^{-8}	1×10^{-7}	1×10^{-7}
D	1×10^{-8}	6×10^{-8}	7×10^{-8}
E	1×10^{-8}	3×10^{-8}	4×10^{-8}
F	3×10^{-9}	8×10^{-9}	1×10^{-8}
G	1×10^{-7}	3×10^{-7}	4×10^{-7}
H	2×10^{-7}	4×10^{-7}	6×10^{-7}
I	1×10^{-7}	2×10^{-7}	4×10^{-7}
J	2×10^{-7}	4×10^{-7}	6×10^{-7}
Vitrification			
A	5×10^{-8}	3×10^{-7}	3×10^{-7}
B	1×10^{-7}	6×10^{-7}	7×10^{-7}
C	2×10^{-8}	1×10^{-7}	2×10^{-7}
D	9×10^{-9}	9×10^{-8}	1×10^{-7}
E	1×10^{-8}	5×10^{-8}	6×10^{-8}
F	2×10^{-9}	1×10^{-8}	1×10^{-8}
G	1×10^{-7}	4×10^{-7}	5×10^{-7}
H	2×10^{-7}	5×10^{-7}	7×10^{-7}
I	1×10^{-7}	3×10^{-7}	4×10^{-7}
J	1×10^{-7}	7×10^{-7}	8×10^{-7}

[a] Based on a risk factor of 6×10^{-7}/mrem (EPA 1989b).

[b] Based on a risk factor of 3.5×10^{-4}/WLM (National Research Council 1988).

TABLE F.18 Estimated Chemical Carcinogenic Risks to Potential Receptors for Alternative 6a, Chemical Stabilization/Solidification

Contaminant/ Exposure Route[a]	Estimated Carcinogenic Risk for the Various Receptors										
	A	B	C	D	E	F	G	H	I	J	K
Metals											
Arsenic											
Inhalation	2×10^{-10}	2×10^{-10}	7×10^{-11}	3×10^{-11}	4×10^{-11}	2×10^{-11}	5×10^{-10}	5×10^{-10}	2×10^{-10}	7×10^{-10}	6×10^{-6}
Ingestion of soil	2×10^{-11}	2×10^{-11}	1×10^{-11}	5×10^{-12}	3×10^{-12}	4×10^{-12}	4×10^{-11}	5×10^{-11}	2×10^{-11}	6×10^{-11}	4×10^{-5}
Beryllium											
Inhalation	5×10^{-12}	3×10^{-12}	1×10^{-12}	7×10^{-13}	1×10^{-12}	3×10^{-13}	1×10^{-11}	8×10^{-12}	3×10^{-12}	2×10^{-11}	2×10^{-7}
Ingestion of soil	2×10^{-12}	2×10^{-12}	9×10^{-13}	5×10^{-13}	3×10^{-13}	3×10^{-13}	6×10^{-12}	5×10^{-12}	2×10^{-12}	9×10^{-12}	5×10^{-6}
Cadmium											
Inhalation	4×10^{-12}	5×10^{-12}	1×10^{-12}	7×10^{-13}	9×10^{-13}	4×10^{-13}	1×10^{-11}	1×10^{-11}	5×10^{-12}	1×10^{-11}	1×10^{-7}
Chromium VI											
Inhalation	5×10^{-11}	4×10^{-11}	2×10^{-11}	8×10^{-12}	1×10^{-11}	4×10^{-12}	2×10^{-10}	9×10^{-11}	4×10^{-11}	3×10^{-10}	2×10^{-6}
Nickel											
Inhalation	3×10^{-11}	2×10^{-11}	1×10^{-11}	5×10^{-12}	7×10^{-12}	2×10^{-12}	1×10^{-10}	5×10^{-11}	2×10^{-11}	2×10^{-10}	1×10^{-6}
PAHs											
Inhalation	9×10^{-9}	5×10^{-9}	3×10^{-9}	1×10^{-9}	2×10^{-9}	6×10^{-10}	3×10^{-8}	1×10^{-8}	4×10^{-9}	5×10^{-8}	2×10^{-7}
Ingestion of soil	1×10^{-14}	1×10^{-14}	5×10^{-15}	3×10^{-15}	2×10^{-15}	2×10^{-15}	4×10^{-14}	3×10^{-14}	9×10^{-15}	8×10^{-14}	2×10^{-5}
PCBs											
Ingestion of soil	3×10^{-11}	2×10^{-11}	2×10^{-11}	9×10^{-12}	6×10^{-12}	8×10^{-12}	5×10^{-11}	1×10^{-10}	6×10^{-11}	7×10^{-11}	7×10^{-6}

TABLE F.18 (Cont.)

Contaminant/ Exposure Route[a]	Estimated Carcinogenic Risk for the Various Receptors										
	A	B	C	D	E	F	G	H	I	J	K
Nitroaromatic compounds											
2,4-DNT Ingestion of soil	4×10^{-14}	4×10^{-14}	3×10^{-14}	1×10^{-14}	8×10^{-15}	9×10^{-15}	8×10^{-14}	2×10^{-13}	8×10^{-14}	5×10^{-14}	NA
2,6-DNT Ingestion of soil	5×10^{-14}	5×10^{-14}	3×10^{-14}	1×10^{-14}	9×10^{-15}	1×10^{-14}	9×10^{-14}	2×10^{-13}	9×10^{-14}	6×10^{-14}	NA
TNT Ingestion of soil	6×10^{-14}	6×10^{-14}	4×10^{-14}	1×10^{-14}	1×10^{-14}	1×10^{-14}	1×10^{-13}	3×10^{-13}	1×10^{-13}	7×10^{-14}	3×10^{-8}
Total risk	9×10^{-9}	5×10^{-9}	3×10^{-9}	1×10^{-9}	2×10^{-9}	6×10^{-10}	3×10^{-8},	1×10^{-8}	4×10^{-9}	5×10^{-8}	8×10^{-5}

[a] Listed are only those contaminants and exposure routes for which an EPA slope factor is available. The EPA slope factors used to estimate the risks are given in Tables 4.4 and 4.5 of the BA (DOE 1992a).

[b] NA indicates that the pathway and/or contaminant is not applicable for that receptor.

TABLE F.19 Estimated Chemical Carcinogenic Risks to Potential Receptors for Alternative 7a, Vitrification

Contaminant/ Exposure Route[a]	Estimated Carcinogenic Risk for the Various Receptors										
	A	B	C	D	E	F	G	H	I	J	K
Metals											
Arsenic											
Inhalation	2×10^{-10}	3×10^{-10}	6×10^{-11}	3×10^{-11}	4×10^{-11}	1×10^{-11}	5×10^{-10}	6×10^{-10}	2×10^{-10}	8×10^{-10}	6×10^{-6}
Ingestion of soil	2×10^{-11}	2×10^{-11}	1×10^{-11}	5×10^{-12}	3×10^{-12}	4×10^{-12}	4×10^{-11}	8×10^{-11}	3×10^{-11}	7×10^{-11}	4×10^{-5}
Beryllium											
Inhalation	5×10^{-12}	4×10^{-12}	1×10^{-12}	6×10^{-13}	9×10^{-13}	3×10^{-13}	1×10^{-11}	9×10^{-12}	4×10^{-12}	3×10^{-11}	2×10^{-7}
Ingestion of soil	2×10^{-12}	2×10^{-12}	8×10^{-13}	5×10^{-13}	3×10^{-13}	3×10^{-13}	5×10^{-12}	7×10^{-12}	2×10^{-12}	1×10^{-11}	5×10^{-6}
Cadmium											
Inhalation	4×10^{-12}	5×10^{-12}	1×10^{-12}	8×10^{-13}	8×10^{-13}	3×10^{-13}	1×10^{-11}	2×10^{-11}	5×10^{-12}	2×10^{-11}	1×10^{-7}
Chromium VI											
Inhalation	5×10^{-11}	5×10^{-11}	2×10^{-11}	7×10^{-12}	1×10^{-11}	4×10^{-12}	2×10^{-10}	1×10^{-10}	4×10^{-11}	4×10^{-10}	2×10^{-6}
Nickel											
Inhalation	3×10^{-11}	3×10^{-11}	9×10^{-12}	4×10^{-12}	6×10^{-12}	2×10^{-12}	9×10^{-11}	6×10^{-11}	3×10^{-11}	2×10^{-10}	1×10^{-6}
PAHs											
Inhalation	9×10^{-9}	6×10^{-9}	2×10^{-9}	1×10^{-9}	2×10^{-9}	5×10^{-10}	3×10^{-8}	1×10^{-8}	5×10^{-9}	6×10^{-8}	2×10^{-7}
Ingestion of soil	1×10^{-14}	1×10^{-14}	5×10^{-15}	3×10^{-15}	2×10^{-15}	2×10^{-15}	4×10^{-14}	4×10^{-14}	1×10^{-14}	8×10^{-14}	2×10^{-5}
PCBs											
Ingestion of soil	3×10^{-11}	5×10^{-11}	2×10^{-11}	9×10^{-12}	5×10^{-12}	7×10^{-12}	5×10^{-11}	2×10^{-10}	9×10^{-11}	7×10^{-11}	7×10^{-6}

TABLE F.19 (Cont.)

Contaminant/ Exposure Route[a]	Estimated Carcinogenic Risk for the Various Receptors[a]										
	A	B	C	D	E	F	G	H	I	J	K
Nitroaromatic compounds											
2,4-DNT Ingestion of soil	6×10^{-14}	6×10^{-14}	3×10^{-14}	2×10^{-14}	1×10^{-14}	1×10^{-14}	1×10^{-13}	4×10^{-13}	1×10^{-13}	9×10^{-14}	NA
2,6-DNT Ingestion of soil	7×10^{-14}	7×10^{-14}	3×10^{-14}	2×10^{-14}	1×10^{-14}	1×10^{-14}	1×10^{-13}	5×10^{-13}	1×10^{-13}	1×10^{-13}	NA
TNT Ingestion of soil	8×10^{-14}	9×10^{-14}	4×10^{-14}	3×10^{-14}	1×10^{-14}	1×10^{-14}	1×10^{-13}	6×10^{-13}	2×10^{-13}	1×10^{-13}	3×10^{-8}
Total risk	9×10^{-9}	6×10^{-9}	2×10^{-9}	3×10^{-9}	2×10^{-9}	5×10^{-10}	3×10^{-8}	1×10^{-8}	5×10^{-9}	6×10^{-8}	8×10^{-5}

[a] Listed are only those contaminants and exposure routes for which an EPA slope factor is available. The EPA slope factors used to estimate the risks are given in Tables 4.4 and 4.5 of the BA (DOE 1992a).

[b] NA indicates that the pathway and/or contaminant is not applicable for that receptor.

TABLE F.20 Estimated Hazard Quotients for Chemical Exposures at Receptor Locations for Alternative 6a, Chemical Stabilization/Solidification

Contaminant/ Exposure Route[b]	Hazard Quotient for the Various Receptors[a]										
	A	B	C	D	E	F	G	H	I	J	K
Metals											
Antimony											
Ingestion of soil	3×10^{-7}	3×10^{-7}	2×10^{-7}	9×10^{-8}	1×10^{-7}	6×10^{-8}	1×10^{-6}	9×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-1}
Arsenic											
Ingestion of soil	3×10^{-7}	3×10^{-7}	2×10^{-7}	9×10^{-8}	1×10^{-7}	7×10^{-8}	8×10^{-7}	1×10^{-6}	4×10^{-7}	1×10^{-6}	8×10^{-1}
Barium											
Inhalation	1×10^{-5}	9×10^{-6}	4×10^{-6}	2×10^{-6}	4×10^{-6}	9×10^{-7}	4×10^{-5}	2×10^{-5}	8×10^{-6}	6×10^{-5}	4×10^{-1}
Ingestion of soil	1×10^{-8}	1×10^{-8}	7×10^{-9}	4×10^{-9}	4×10^{-9}	2×10^{-9}	4×10^{-8}	3×10^{-8}	1×10^{-8}	6×10^{-8}	3×10^{-2}
Beryllium											
Ingestion of soil	8×10^{-10}	7×10^{-10}	4×10^{-10}	2×10^{-10}	3×10^{-10}	2×10^{-10}	3×10^{-9}	2×10^{-9}	7×10^{-10}	4×10^{-9}	2×10^{-3}
Cadmium											
Inhalation	4×10^{-8}	4×10^{-8}	1×10^{-8}	5×10^{-9}	1×10^{-8}	3×10^{-9}	9×10^{-8}	1×10^{-7}	4×10^{-8}	1×10^{-7}	1×10^{-3}
Ingestion of soil	4×10^{-9}	4×10^{-9}	3×10^{-9}	1×10^{-9}	1×10^{-9}	9×10^{-10}	1×10^{-8}	1×10^{-8}	6×10^{-9}	1×10^{-8}	1×10^{-2}
Chromium III											
Inhalation	2×10^{-4}	1×10^{-4}	6×10^{-5}	3×10^{-5}	7×10^{-5}	1×10^{-5}	6×10^{-4}	3×10^{-4}	1×10^{-4}	1×10^{-3}	8
Ingestion of soil	8×10^{-11}	8×10^{-11}	4×10^{-11}	2×10^{-11}	3×10^{-11}	2×10^{-11}	3×10^{-10}	2×10^{-10}	7×10^{-11}	4×10^{-10}	3×10^{-4}
Chromium VI											
Inhalation	2×10^{-5}	2×10^{-5}	7×10^{-6}	3×10^{-6}	8×10^{-6}	2×10^{-6}	7×10^{-5}	4×10^{-5}	1×10^{-5}	1×10^{-4}	9×10^{-1}
Ingestion of soil	2×10^{-9}	2×10^{-9}	1×10^{-9}	5×10^{-10}	6×10^{-10}	4×10^{-10}	7×10^{-9}	5×10^{-9}	2×10^{-9}	1×10^{-8}	7×10^{-3}
Copper											
Ingestion of soil	3×10^{-9}	2×10^{-9}	1×10^{-9}	7×10^{-10}	9×10^{-10}	5×10^{-10}	9×10^{-9}	8×10^{-9}	2×10^{-9}	1×10^{-8}	6×10^{-3}
Lithium											
Ingestion of soil	2×10^{-9}	2×10^{-9}	8×10^{-10}	5×10^{-10}	6×10^{-10}	3×10^{-10}	6×10^{-9}	5×10^{-9}	1×10^{-9}	9×10^{-9}	6×10^{-3}

TABLE F.20 (Cont.)

Contaminant/ Exposure Route[b]	Hazard Quotient for the Various Receptors[a]										
	A	B	C	D	E	F	G	H	I	J	K
Metals (cont.)											
Manganese											
Inhalation	4×10^{-5}	3×10^{-5}	1×10^{-5}	6×10^{-6}	1×10^{-5}	3×10^{-6}	1×10^{-4}	6×10^{-5}	3×10^{-5}	2×10^{-4}	1
Ingestion of soil	3×10^{-8}	3×10^{-8}	2×10^{-8}	9×10^{-9}	1×10^{-8}	6×10^{-9}	9×10^{-8}	7×10^{-8}	2×10^{-8}	1×10^{-7}	8×10^{-2}
Mercury											
Inhalation	9×10^{-9}	1×10^{-8}	3×10^{-9}	1×10^{-9}	3×10^{-9}	7×10^{-10}	2×10^{-8}	3×10^{-8}	1×10^{-8}	3×10^{-8}	2×10^{-4}
Ingestion of soil	2×10^{-9}	2×10^{-9}	1×10^{-9}	5×10^{-10}	5×10^{-10}	4×10^{-10}	4×10^{-9}	6×10^{-9}	2×10^{-9}	5×10^{-9}	4×10^{-3}
Molybdenum											
Ingestion of soil	3×10^{-8}	3×10^{-8}	2×10^{-8}	8×10^{-9}	9×10^{-9}	6×10^{-9}	8×10^{-8}	8×10^{-8}	3×10^{-8}	1×10^{-7}	7×10^{-2}
Nickel											
Ingestion of soil	6×10^{-9}	6×10^{-9}	3×10^{-9}	2×10^{-9}	2×10^{-9}	1×10^{-9}	2×10^{-8}	2×10^{-8}	6×10^{-9}	3×10^{-8}	2×10^{-2}
Selenium											
Ingestion of soil	1×10^{-9}	2×10^{-9}	9×10^{-10}	4×10^{-10}	5×10^{-10}	3×10^{-10}	4×10^{-9}	5×10^{-9}	2×10^{-9}	6×10^{-9}	1×10^{-2}
Silver											
Ingestion of soil	7×10^{-10}	7×10^{-10}	4×10^{-10}	2×10^{-10}	2×10^{-10}	1×10^{-10}	3×10^{-9}	2×10^{-9}	6×10^{-10}	3×10^{-9}	2×10^{-3}
Thallium											
Ingestion of soil	4×10^{-8}	4×10^{-8}	3×10^{-8}	1×10^{-8}	1×10^{-8}	9×10^{-9}	1×10^{-7}	1×10^{-7}	5×10^{-8}	1×10^{-7}	6×10^{-1}
Uranium											
Ingestion of soil	2×10^{-7}	2×10^{-7}	1×10^{-7}	6×10^{-8}	6×10^{-8}	4×10^{-8}	5×10^{-7}	5×10^{-7}	2×10^{-7}	7×10^{-7}	5×10^{-1}
Vanadium											
Ingestion of soil	4×10^{-8}	4×10^{-8}	3×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-8}	1×10^{-7}	1×10^{-7}	7×10^{-8}	2×10^{-7}	7×10^{-2}
Zinc											
Ingestion of soil	2×10^{-9}	2×10^{-9}	8×10^{-10}	4×10^{-10}	6×10^{-10}	3×10^{-10}	7×10^{-9}	4×10^{-9}	1×10^{-9}	9×10^{-9}	6×10^{-3}

TABLE F.20 (Cont.)

Contaminant/ Exposure Route[b]	Hazard Quotient for the Various Receptors[a]										
	A	B	C	D	E	F	G	H	I	J	K
Inorganic anions											
Fluoride Ingestion of soil	4×10^{-10}	4×10^{-10}	2×10^{-10}	1×10^{-10}	1×10^{-10}	8×10^{-11}	1×10^{-9}	1×10^{-9}	3×10^{-10}	2×10^{-9}	1×10^{-3}
Nitrate Ingestion of soil	1×10^{-9}	1×10^{-9}	9×10^{-10}	4×10^{-10}	4×10^{-10}	3×10^{-10}	2×10^{-9}	4×10^{-9}	2×10^{-9}	2×10^{-9}	9×10^{-4}
Nitrite Ingestion of soil	2×10^{-10}	2×10^{-10}	1×10^{-10}	6×10^{-11}	6×10^{-11}	5×10^{-11}	3×10^{-10}	6×10^{-10}	4×10^{-10}	4×10^{-10}	8×10^{-5}
PAHs											
Ingestion of soil	3×10^{-13}	3×10^{-13}	2×10^{-13}	9×10^{-14}	1×10^{-13}	6×10^{-14}	1×10^{-12}	1×10^{-12}	4×10^{-13}	2×10^{-12}	4×10^{-3}
PCBs											
Ingestion of soil	4×10^{-7}	4×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-2}
Nitroaromatic compounds											
DNB Ingestion of soil	7×10^{-8}	7×10^{-8}	3×10^{-8}	2×10^{-8}	3×10^{-8}	1×10^{-8}	3×10^{-7}	2×10^{-7}	5×10^{-8}	4×10^{-7}	2×10^{-2}
2,4-DNT Ingestion of soil	3×10^{-9}	3×10^{-9}	2×10^{-9}	7×10^{-10}	1×10^{-9}	7×10^{-10}	6×10^{-9}	1×10^{-8}	6×10^{-9}	4×10^{-9}	NA
2,6-DNT Ingestion of soil	2×10^{-10}	2×10^{-10}	1×10^{-10}	4×10^{-11}	6×10^{-11}	4×10^{-11}	3×10^{-10}	8×10^{-10}	3×10^{-10}	2×10^{-10}	NA

TABLE F.20 (Cont.)

Contaminant/ Exposure Route[b]	Hazard Quotient for the Various Receptors[a]										
	A	B	C	D	E	F	G	H	I	J	K
Nitroaromatic compounds (cont.)											
NB											
Inhalation	2×10^{-8}	3×10^{-8}	6×10^{-9}	4×10^{-9}	7×10^{-9}	2×10^{-9}	3×10^{-8}	1×10^{-7}	3×10^{-8}	3×10^{-8}	NA
Ingestion of soil	1×10^{-6}	1×10^{-6}	7×10^{-9}	3×10^{-9}	4×10^{-9}	3×10^{-9}	2×10^{-8}	5×10^{-8}	2×10^{-8}	1×10^{-6}	NA
TNB											
Ingestion of soil	2×10^{-7}	2×10^{-7}	1×10^{-7}	5×10^{-6}	7×10^{-8}	5×10^{-8}	4×10^{-7}	9×10^{-7}	4×10^{-7}	2×10^{-7}	NA
TNT											
Ingestion of soil	4×10^{-8}	4×10^{-5}	2×10^{-8}	9×10^{-9}	1×10^{-8}	8×10^{-9}	7×10^{-8}	2×10^{-7}	7×10^{-8}	5×10^{-8}	2×10^{-2}
Hazard index	0.0003	0.0002	0.00008	0.00004	0.00009	0.00002	0.0008	0.0004	0.0002	0.001	10

[a] Calculated by dividing the average daily intake over the exposure period by the chemical-specific reference dose. The individual hazard quotients are summed to calculate the hazard index. A hazard index of less than or equal to one is considered to indicate a nonhazardous situation; a hazard index of greater than one is considered to indicate a potential for adverse health effects.

[b] Listed are only those contaminants for which an EPA inhalation and/or oral reference dose is available. The EPA reference doses used to estimate the hazard quotients are given in Tables 4.2 and 4.3 of the BA (DOE 1992a).

[c] NA indicates that the pathway and/or contaminant is not applicable for that receptor.

TABLE F.21 Estimated Hazard Quotients for Chemical Exposures at Receptor Locations for Alternative 7a, Vitrification

Contaminant/ Exposure Route[b]	Hazard Quotient for the Various Receptors[a]										
	A	B	C	D	E	F	G	H	I	J	K
Metals											
Antimony											
Ingestion of soil	3×10^{-7}	4×10^{-7}	1×10^{-7}	9×10^{-8}	1×10^{-7}	5×10^{-8}	1×10^{-6}	1×10^{-6}	3×10^{-7}	2×10^{-6}	2×10^{-1}
Arsenic											
Ingestion of soil	3×10^{-7}	4×10^{-7}	2×10^{-7}	1×10^{-7}	1×10^{-7}	6×10^{-8}	8×10^{-7}	2×10^{-6}	5×10^{-7}	1×10^{-6}	8×10^{-1}
Barium											
Inhalation	1×10^{-5}	1×10^{-5}	4×10^{-6}	2×10^{-6}	4×10^{-6}	8×10^{-7}	4×10^{-6}	2×10^{-5}	1×10^{-5}	8×10^{-5}	4×10^{-1}
Ingestion of soil	1×10^{-8}	2×10^{-8}	6×10^{-9}	3×10^{-9}	4×10^{-9}	2×10^{-9}	4×10^{-8}	5×10^{-8}	1×10^{-8}	7×10^{-8}	3×10^{-2}
Beryllium											
Ingestion of soil	7×10^{-10}	1×10^{-9}	4×10^{-10}	2×10^{-10}	2×10^{-10}	1×10^{-10}	2×10^{-9}	3×10^{-9}	9×10^{-10}	5×10^{-9}	2×10^{-3}
Cadmium											
Inhalation	3×10^{-8}	4×10^{-8}	1×10^{-8}	6×10^{-9}	1×10^{-8}	2×10^{-9}	8×10^{-8}	1×10^{-7}	4×10^{-8}	1×10^{-7}	1×10^{-3}
Ingestion of soil	4×10^{-9}	6×10^{-9}	2×10^{-9}	2×10^{-9}	1×10^{-9}	9×10^{-10}	1×10^{-8}	3×10^{-8}	8×10^{-9}	2×10^{-8}	1×10^{-2}
Chromium III											
Inhalation	2×10^{-4}	2×10^{-4}	6×10^{-5}	3×10^{-5}	7×10^{-5}	1×10^{-5}	6×10^{-4}	4×10^{-4}	2×10^{-4}	1×10^{-3}	8
Ingestion of soil	7×10^{-11}	1×10^{-10}	4×10^{-11}	2×10^{-11}	3×10^{-11}	2×10^{-11}	3×10^{-10}	3×10^{-10}	8×10^{-11}	5×10^{-10}	3×10^{-4}
Chromium VI											
Inhalation	2×10^{-5}	2×10^{-5}	6×10^{-6}	3×10^{-6}	8×10^{-6}	1×10^{-6}	7×10^{-5}	4×10^{-5}	2×10^{-5}	1×10^{-4}	9×10^{-1}
Ingestion of soil	2×10^{-9}	2×10^{-9}	9×10^{-10}	5×10^{-10}	6×10^{-10}	3×10^{-10}	6×10^{-9}	8×10^{-9}	2×10^{-9}	1×10^{-8}	7×10^{-3}
Copper											
Ingestion of soil	2×10^{-9}	3×10^{-9}	1×10^{-9}	8×10^{-10}	8×10^{-10}	5×10^{-10}	8×10^{-9}	1×10^{-8}	3×10^{-9}	2×10^{-8}	6×10^{-3}
Lithium											
Ingestion of soil	1×10^{-9}	2×10^{-9}	8×10^{-10}	4×10^{-10}	5×10^{-10}	3×10^{-10}	6×10^{-9}	6×10^{-9}	2×10^{-9}	1×10^{-8}	6×10^{-3}

TABLE F.21 (Cont.)

Contaminant/ Exposure Route[b]	Hazard Quotient for the Various Receptors[a]										
	A	B	C	D	E	F	G	H	I	J	K
Metals (cont.)											
Manganese											
Inhalation	4×10^{-5}	4×10^{-5}	1×10^{-5}	6×10^{-6}	1×10^{-5}	3×10^{-6}	1×10^{-4}	7×10^{-5}	4×10^{-5}	2×10^{-4}	1
Ingestion of soil	3×10^{-8}	4×10^{-8}	2×10^{-8}	9×10^{-9}	9×10^{-9}	5×10^{-9}	8×10^{-8}	1×10^{-7}	3×10^{-8}	2×10^{-7}	8×10^{-2}
Mercury											
Inhalation	8×10^{-9}	1×10^{-8}	3×10^{-9}	2×10^{-9}	3×10^{-9}	6×10^{-10}	2×10^{-8}	3×10^{-8}	1×10^{-8}	3×10^{-8}	2×10^{-4}
Ingestion of soil	2×10^{-9}	2×10^{-9}	1×10^{-9}	6×10^{-10}	5×10^{-10}	4×10^{-10}	4×10^{-9}	1×10^{-8}	3×10^{-9}	6×10^{-9}	4×10^{-3}
Molybdenum											
Ingestion of soil	2×10^{-8}	4×10^{-8}	1×10^{-8}	8×10^{-9}	8×10^{-9}	5×10^{-9}	7×10^{-8}	1×10^{-7}	4×10^{-8}	1×10^{-7}	7×10^{-2}
Nickel											
Ingestion of soil	6×10^{-9}	8×10^{-9}	3×10^{-9}	2×10^{-9}	2×10^{-9}	1×10^{-9}	2×10^{-8}	3×10^{-8}	7×10^{-9}	4×10^{-8}	2×10^{-2}
Selenium											
Ingestion of soil	1×10^{-9}	2×10^{-9}	8×10^{-10}	5×10^{-10}	5×10^{-10}	3×10^{-10}	4×10^{-9}	8×10^{-9}	2×10^{-9}	8×10^{-9}	1×10^{-2}
Silver											
Ingestion of soil	7×10^{-10}	9×10^{-10}	3×10^{-10}	2×10^{-10}	2×10^{-10}	1×10^{-10}	3×10^{-9}	3×10^{-9}	8×10^{-10}	4×10^{-9}	2×10^{-3}
Thallium											
Ingestion of soil	4×10^{-8}	6×10^{-8}	2×10^{-8}	1×10^{-8}	1×10^{-8}	9×10^{-9}	1×10^{-7}	2×10^{-7}	6×10^{-8}	2×10^{-7}	6×10^{-1}
Uranium											
Ingestion of soil	2×10^{-7}	3×10^{-7}	1×10^{-7}	7×10^{-8}	6×10^{-8}	4×10^{-8}	5×10^{-7}	9×10^{-7}	3×10^{-7}	9×10^{-7}	5×10^{-1}
Vanadium											
Ingestion of soil	4×10^{-8}	6×10^{-8}	3×10^{-8}	1×10^{-8}	1×10^{-8}	9×10^{-9}	1×10^{-7}	2×10^{-7}	9×10^{-8}	2×10^{-7}	7×10^{-2}
Zinc											
Ingestion of soil	1×10^{-9}	2×10^{-9}	7×10^{-10}	4×10^{-10}	5×10^{-10}	3×10^{-10}	6×10^{-9}	6×10^{-9}	1×10^{-9}	1×10^{-8}	6×10^{-3}

TABLE F.21 (Cont.)

Contaminant/ Exposure Route[b]	Hazard Quotient for the Various Receptors[a]										
	A	B	C	D	E	F	G	H	I	J	K
Inorganic anions											
Fluoride											
Ingestion of soil	4×10^{-10}	2×10^{-9}	8×10^{-10}	4×10^{-10}	3×10^{-10}	3×10^{-10}	2×10^{-9}	6×10^{-9}	3×10^{-9}	3×10^{-9}	1×10^{-3}
Nitrate											
Ingestion of soil	9×10^{-10}	2×10^{-9}	8×10^{-10}	4×10^{-10}	3×10^{-10}	3×10^{-10}	2×10^{-9}	6×10^{-9}	3×10^{-9}	3×10^{-9}	9×10^{-4}
Nitrite											
Ingestion of soil	1×10^{-10}	3×10^{-10}	1×10^{-10}	6×10^{-11}	5×10^{-11}	4×10^{-11}	3×10^{-10}	1×10^{-9}	5×10^{-10}	4×10^{-10}	8×10^{-5}
PAHs											
Ingestion of soil	3×10^{-13}	4×10^{-13}	2×10^{-13}	9×10^{-14}	1×10^{-13}	6×10^{-14}	1×10^{-12}	1×10^{-12}	4×10^{-13}	3×10^{-12}	4×10^{-3}
PCBs											
Ingestion of soil	3×10^{-7}	1×10^{-6}	3×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-7}	1×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-6}	9×10^{-2}
Nitroaromatic compounds											
DNB											
Ingestion of soil	6×10^{-8}	8×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	1×10^{-8}	2×10^{-7}	3×10^{-7}	6×10^{-8}	5×10^{-7}	2×10^{-2}
2,4-DNT											
Ingestion of soil	4×10^{-9}	5×10^{-9}	2×10^{-9}	2×10^{-9}	1×10^{-9}	8×10^{-10}	7×10^{-9}	3×10^{-8}	9×10^{-9}	6×10^{-9}	NA
2,6-DNT											
Ingestion of soil	2×10^{-10}	3×10^{-10}	1×10^{-10}	9×10^{-11}	8×10^{-11}	4×10^{-11}	4×10^{-10}	2×10^{-9}	5×10^{-10}	4×10^{-10}	NA

TABLE F.21 (Cont.)

Contaminant/ Exposure Route[b]	Hazard Quotient for the Various Receptors[a]										
	A	B	C	D	E	F	G	H	I	J	K
Nitroaromatic compounds (cont.)											
NB											
Inhalation	2×10^{-8}	3×10^{-8}	8×10^{-9}	5×10^{-9}	6×10^{-9}	1×10^{-9}	3×10^{-8}	1×10^{-7}	3×10^{-8}	4×10^{-8}	NA
Ingestion of soil	2×10^{-8}	2×10^{-8}	8×10^{-9}	6×10^{-9}	5×10^{-9}	3×10^{-9}	3×10^{-8}	1×10^{-7}	3×10^{-8}	2×10^{-8}	NA
TNB											
Ingestion of soil	3×10^{-7}	3×10^{-7}	1×10^{-7}	1×10^{-7}	9×10^{-8}	5×10^{-8}	5×10^{-7}	2×10^{-6}	6×10^{-7}	4×10^{-7}	NA
TNT											
Ingestion of soil	5×10^{-8}	6×10^{-8}	3×10^{-8}	2×10^{-8}	2×10^{-8}	1×10^{-8}	9×10^{-8}	4×10^{-7}	1×10^{-7}	8×10^{-8}	2×10^{-2}
Hazard index	0.0003	0.0003	0.00008	0.00004	0.00009	0.00002	0.0008	0.0005	0.0003	0.001	10

[a] Calculated by dividing the average daily intake over the exposure period by the chemical-specific reference dose. The individual hazard quotients are summed to calculate the hazard index. A hazard index of less than or equal to one is considered to indicate a nonhazardous situation; a hazard index of greater than one is considered to indicate a potential for adverse health effects.

[b] Listed are only those contaminants for which an EPA inhalation and/or oral reference dose is available. The EPA reference doses used to estimate the hazard quotients are given in Tables 4.2 and 4.3 of the BA (DOE 1992a).

[c] NA indicates that the pathway and/or contaminant is not applicable for that receptor.

TABLE F.22 Estimated Numbers of Occupational Fatalities, Injuries, and Related Lost Workdays Associated with Implementation of the Final Remedial Action Alternatives

Category	Estimated Number[a]			
	Alternative 6a[b]	Alternative 7a[c]	Alternative 7b[d]	Alternative 7c[d]
Total number of occupational fatalities[e]	0.14	0.20	0.28	0.28
Total cases of occupational injuries[f]	82	110	160	160
Total cases of occupational injuries without lost workdays[f]	45	63	89	89
Total cases of occupational injuries with lost workdays[f,g]	37	51	72	72
Total lost workdays due to occupational injuries[f,g]	790	1,100	1,600	1,600

[a] All estimates are based on average rates for 1985 to 1988, calculated from annual estimates provided by the U.S. Department of Labor (1988, 1990). The latest year for which results are available is 1988. Averages are used to reduce year-to-year variations in rates. All estimates are rounded to two significant figures.

[b] Based on 560 person-years of effort. Assumes an 8-hour workday. Long-term monitoring and maintenance are not included.

[c] Based on 780 person-years of effort. Assumes an 8-hour workday. Long-term monitoring and maintenance are not included.

[d] Based on 1,100 person-years of effort. Assumes an 8-hour workday. Disposal activities are assumed to require the same effort as for Alternative 7a. Long-term monitoring and maintenance are not included.

[e] Based on results for the construction industry. Because of the relatively small number of occupational fatalities that occur annually in each category of the construction industry, the incidence rate for fatalities is provided by the Department of Labor only for the construction industry as a whole and not for various categories. The annual average rate for the 1985-1988 period is 25.2 fatalities per 100,000 full-time workers.

[f] Based on results for heavy construction, except highways.

[g] Includes cases that involve days away from work, days of restricted activity, or both.

TABLE F.23 Summary of Transportation Requirements for the Final Action Alternatives[a]

Alternative/ Material	Route	Vehicle	Assumed Vehicle Capacity (yd^3)	Total Quantity (10^6 yd^3)	Number of Vehicle Trips	One-Way Haul Distance (km)
Alternative 6a						
Fill	Off-site to site	Truck	20	1.52	76,000	-[b]
Fly ash	Off-site to site	Truck	-[c]	136,000 tons	4,860	<40
Cement	Off-site to site	Truck	-[c]	91,000 tons	3,250	<160
Contaminated material (lakes)	Off-site to site	Truck	10	0.020	2,000	≤4.3
Contaminated material (vicinity properties)	Off-site to site	Truck	10	0.0036	360	<3
Process chemicals	Site to incinerator[d]	Truck	88 drums	500 drums	6	820
Alternative 7a						
Fill	Off-site to site	Truck	20	1.33	67,000	-[e]
Contaminated material (lakes)	Off-site to site	Truck	10	0.020	2,000	≤4.3
Contaminated material (vicinity properties)	Off-site to site	Truck	10	0.0036	360	<3
Process chemicals	Site to incinerator[d]	Truck	88 drums	500 drums	6	820
Alternative 7b						
Fill	Off-site to site	Truck	20	0.535	27,000	-[f]
Contaminated material	Site to Wentzville	Truck	-[c]	1.08×10^6 tons	38,600	24
Contaminated material	Wentzville to Clive	Railcar	-[g]	1.08×10^6 tons	12,900	2,400
Contaminated material (lakes)	Off-site to site	Truck	10	0.020	2,000	≤4.3
Contaminated material (vicinity properties)	Off-site to site	Truck	10	0.0036	360	<3
Process chemicals	Site to incinerator[d]	Truck	88 drums	500 drums	6	820
Alternative 7c						
Fill	Off-site to site	Truck	20	0.535	27,000	-[f]
Contaminated material	Site to Wentzville	Truck	-[c]	1.08×10^6 tons	38,600	24
Contaminated material	Wentzville to Hanford	Railcar	-[g]	1.08×10^6 tons	12,900	3,400
Contaminated material (lakes)	Off-site to site	Truck	10	0.020	2,000	≤4.3
Contaminated material (vicinity properties)	Off-site to site	Truck	10	0.0036	360	<3
Process chemicals	Site to incinerator[d]	Truck	88 drums	500 drums	6	820

[a] All units as given in column headings, except as noted.

[b] 75% of the trips are assumed to be 2 km (1.2 mi) one way; the balance are assumed to be less than 24 km (15 mi) one way.

[c] Weight-limited load is 25 tons; based on a total weight limit of 40 tons and a truck and container weight of 12 tons.

[d] To provide a representative scenario for analysis in this assessment, the incinerator is assumed to be located in Oak Ridge, Tennessee.

[e] 80% of the trips are assumed to be 2 km (1.2 mi) one way; the balance are assumed to be less than 24 km (15 mi) one way.

[f] 92% of the trips are assumed to be 2 km (1.2 mi) one way; the balance are assumed to be less than 24 km (15 mi) one way.

[g] Capacity of a railcar is 84 tons; this value is based on three 28-ton containers per railcar.

TABLE F.24 Volumes and Radioactivity Concentrations of Material for Transport under Alternative 7b or 7c

Material	Volume[a] (yd^3)	Radioactivity Concentration (pCi/g) Actinium-227	Lead-210	Protactinium-231	Radium-226	Radium-228
Vitrified material[b]	102,000	440	590	580	520	220
Soil/sediment						
Ash Pond[c]	25,100	3.6	26	7.2	26	14
North Dump	7,600	2.5	18	5.0	18	9.9
Frog Pond[d]	7,000	1.2	11	2.5	11	5.9
Busch lakes[e]	20,000	0.57	4.2	1.1	4.2	2.3
Chemical plant area[f]	87,100	0.42	3.1	0.83	3.1	1.7
Quarry sediment and soil[g]	6,100	0.58	34	0.12	11	9.6
Raffinate pit area soil	103,500	0.63	4.6	1.3	4.6	2.5
Chipped wood and vegetation[h]	30,650	1.2	11	2.5	11	5.9
Roads and embankments[i]	76,930	1.2	11	2.5	11	5.9
TSA area[j]	4,100	1.2	11	2.5	11	5.9
Vicinity properties[k]						
Army 1	1,160	5.3	39	11	39	21
Army 2	180	1.0	18	2.0	18*	4.0
Army 3	60	1.2	8.7	2.4	8.7	4.7
Army 5 and 6	1,700	0.29	30	0.57	30*	1.1
Busch 4	450	0.25	120	0.49	120*	1.0
Busch 3 and 5	50	4.0	29	8.0	29	16
Building debris						
Quarry bulk metal and rock/concrete[g]	40,700	0.06	34	0.12	11	9.6
Building debris from MSA[l] and facilities closure	162,300	0.57	4.2	1.1	4.2	2.3

Material	Volume[a] (yd^3)	Radioactivity Concentration (pCi/g) Thorium-230	Thorium-232	Uranium-235	Uranium-238
Vitrified material[b]	102,000	19,900	29	41	850
Soil/sediment					
Ash Pond[c]	25,100	29	14	8.6	190
North Dump	7,600	20	9.9	6.0	130
Frog Pond[d]	7,000	5.2	5.9	3.0	65
Busch lakes[e]	20,000	4.5	2.3	1.4	30
Chemical plant area[f]	87,100	3.3	1.7	1.0	22
Quarry sediment and soil[g]	6,100	33	2.6	0.92	20
Raffinate pit area soil	103,500	5.0	2.5	1.5	33
Chipped wood and vegetation[h]	30,650	5.2	5.9	3.0	65
Roads and embankments[i]	76,930	5.2	5.9	3.0	65
TSA area[j]	4,100	5.2	5.9	3.0	65

TABLE F.24 (Cont.)

Material	Volume[a] (yd^3)	Radioactivity Concentration (pCi/g)			
		Thorium-230	Thorium-232	Uranium-235	Uranium-238
Vicinity properties[k]					
Army 1	1,160	42	21	13	280*
Army 2	180	8.0	6.0	2.4	53*
Army 3	60	9.3	4.7	2.9	62*
Army 5 and 6	1,700	2.3	1.1	0.69	15*
Busch 4	450	44*	1.0	0.60	13*
Busch 3 and 5	50	210*	16	9.7	210*
Building debris					
Quarry bulk metal and rock/concrete[g]	40,700	33	2.6	0.92	20
Building debris from MSA[l] and facilities closure	162,300	4.5	2.3	1.4	30

[a] The waste volumes listed in this table represent the total volumes of materials that might be transported off-site for Alternative 7b or 7c. As such, this table includes additional entries beyond those given in Tables F.3 and F.4, i.e., to account for material in temporary storage on-site and material that might become contaminated as a result of implementing the action alternative.

[b] The material targeted for vitrification consists of quarry soil, raffinate pit sludge, and soil under the raffinate pits.

[c] The Ash Pond concentrations and volume include the contribution from the South Dump; these areas were treated as a single source area because they are located in proximity and are part of the same drainage system.

[d] The UL_{95} concentrations for sitewide soil were used for this material.

[e] Based on information provided in MK-Ferguson Company and Jacobs Engineering Group (1989).

[f] Includes soil around the chemical plant buildings, soil beneath the buildings, soil around pipes and sewers, and soil in the site water treatment plant area.

[g] The activity concentrations in this material are assumed to be 10% of those for quarry soil that is vitrified; the material is assumed to be in storage at the TSA.

[h] Volume of material in the mulch pile. The UL_{95} concentrations for sitewide soil were used for this material.

[i] Areas assumed to become contaminated as a result of implementing the action alternative. The UL_{95} concentrations for sitewide soil were used for this material.

[j] Volume of contaminated soil resulting from construction of the TSA; this material is assumed to be in storage at the MSA. The UL_{95} concentrations for sitewide soil were used for this material.

[k] Source: DOE (1992a). The average value for vicinity properties was used. An asterisk (*) following a value denotes a measured value. The radiological source term analysis for chemical plant area soil (Table 2.3 of the BA) was used to estimate the concentrations of radionuclides not measured.

[l] Based on information provided in Peterson and MacDonell (1991). Because the structures will be extensively decontaminated prior to dismantlement, the levels of residual contamination will be very low. The radionuclides are assumed to be present in the same activity concentration ratios as are present in soil at the chemical plant area.

TABLE F.25 Estimated Number of Transportation-Related Accidents and Fatalities for the Final Remedial Action Alternatives

Alternative/ Material	Vehicle	Total Distance Traveled[a] (10^6 vehicle-km)	Number of Accidents	Number of Fatalities
Alternative 6a				
Fill	Truck	1.14	2.3[b]	0.020[b]
Supplies	Truck	1.43	2.8[b]	0.025[b]
Contaminated material	Truck	0.02	0.04[b]	0.0003[b]
Process chemicals	Truck	0.01	0.003[c]	0.0002[c]
Total			5.1	0.046
Alternative 7a				
Fill	Truck	0.86	1.7[b]	0.015[b]
Contaminated material	Truck	0.02	0.04[b]	0.0003[b]
Process chemicals	Truck	0.01	0.003[c]	0.0002[c]
Total			1.7	0.016
Alternative 7b				
Fill	Truck	0.20	0.39[b]	0.003[b]
Contaminated material	Truck	1.87	2.5[d]	0.024[d]
Process chemicals	Truck	0.01	0.003[c]	0.0002[c]
Contaminated material	Railcar	61.9	3.4[e]	0.040[e]
Total			6.3	0.067
Alternative 7c				
Fill	Truck	0.20	0.39[b]	0.003[b]
Contaminated material	Truck	1.87	2.5[d]	0.024[d]
Process chemicals	Truck	0.01	0.003[c]	0.0002[c]
Contaminated material	Railcar	87.7	4.9[e]	0.057[e]
Total			7.8	0.084

[a] Includes empty returns. Distances are based on number of trips and distances in Table F.23. Vehicle-km means railcar-km for rail transportation.

[b] Based on an accident rate of 1.97×10^{-6} per vehicle-km and a fatality rate of 1.72×10^{-8} per vehicle-km for Missouri state-numbered routes for 1989 (Brocksmith 1991). An accident is defined as involving injury or property damage of $500 or more.

[c] Based on average statewide accident and fatality rates for highway combination trucks for the states of Illinois, Kentucky, Missouri, and Tennessee for interstate highways for the period 1986-1988 (Saricks 1991a), weighted by the portion of the route in these states. Accident involvement rates are 3.53×10^{-7}, 1.99×10^{-7}, 2.61×10^{-7}, and 2.48×10^{-7} per shipment-km, respectively. Fatality rates are 2.38×10^{-8}, 1.75×10^{-8}, 1.99×10^{-8}, and 2.24×10^{-8} fatalities per shipment-km, respectively. Accidents were defined as involving injury or property damage of $4,200, $4,400, or $4,900 or more for 1986, 1987, and 1988, respectively.

[d] Based on a 1989 accident rate of 1.36×10^{-6} per vehicle-km and a fatality rate of 1.29×10^{-8} per vehicle-km for U.S.-numbered routes in Missouri (Brocksmith 1991). An accident is defined as involving injury or property damage of $500 or more.

[e] Based on an accident rate of 5.57×10^{-8} per railcar-km and a fatality rate of 6.5×10^{-10} per railcar-km, the 1986-1988 averages for U.S. railroads (Saricks 1991b).

TABLE F.26 Parameters for Analysis of Incident-Free Transportation for Alternatives 7b and 7c

Parameter	Rail	Truck
Velocity in population zones[a] (km/h)		
Rural	64.4	88.6
Suburban	40.3	40.3
Urban	24.1	24.1
Number of crew members[a]	5	2
Distance from source to crew[a,b] (m)	152	10
Stop time per kilometer[a] (h/km)	0.033	0
Number of classifications/inspections[a]	2	0
Persons exposed while stopped[c]	100	3
Exposure distance while stopped[c] (m)	20	4
Number of persons per vehicle on transport link[a]	3	2
Population densities[a] (persons/km^2)		
Rural	6	6
Suburban	719	719
Urban	3,861	3,861
Number of shipments[c]		
Vitrified material	87	6,500
Soil, sediment, debris	428	32,100
Number of containers per shipment[c]	75	1
Transport index[c] (mrem/h at 1 m)		
Vitrified material	0.3	0.3
Soil, sediment, building debris	0.1	0.1

[a] RADTRAN 4 default parameters (Neuhauser and Kanipe 1991).

[b] Distance adjusted to account for shielding effects of the transport vehicle (see Neuhauser and Kanipe 1991).

[c] Values based on scenario-specific assumptions.

TABLE F.27 Impacts from Incident-Free Transportation of Radioactive Material for Alternatives 7b and 7c

Alternative	Transport Mode	Route	Receptor	Maximum Individual[a] Dose (mrem)	Maximum Individual[a] Risk
7b, 7c	Truck	Site to Wentzville[b]	Crew member	6.4	4×10^{-6}
			Waste handler[c]	100	6×10^{-5}
			Member of the public[d]	0.11	7×10^{-8}
7b	Rail	Wentzville to Clive	Crew member	13	8×10^{-6}
			Member of the public[d]	0.040	2×10^{-8}
7c	Rail	Wentzville to Hanford	Crew member	17	1×10^{-5}
			Member of the public[d]	0.040	2×10^{-8}

Alternative	Transport Mode	Route	Receptors	Population[a] Dose (person-rem)	Population[a] Risk
7b, 7c	Truck	Site to Wentzville[b]	Crew members	0.18	1×10^{-4}
			Waste handlers[c]	1.1	7×10^{-4}
			Members of the public[d]	0.12	7×10^{-5}
7b	Rail	Wentzville to Clive	Crew members	0.18	1×10^{-4}
			Members of the public[d]	4.4	3×10^{-3}
7c	Rail	Wentzville to Hanford	Crew members	0.22	1×10^{-4}
			Members of the public[d]	5.8	3×10^{-3}

[a] The doses and health effects to the crew member and waste handler are annual values and are for shipment of the vitrified material; the corresponding values averaged over the entire shipment campaign are lower by about a factor of two. The doses and health effects to a member of the public are for the entire shipment campaign.

[b] Includes the impacts associated with transporting contaminated material from the vicinity properties to the chemical plant area.

[c] The handler was assumed to operate a translift at the Wentzville siding and transfer 33 containers per day from trucks to railcars.

[d] Members of the public include all persons living in the vicinity of transport routes, persons sharing transport routes, and persons at stops along transport routes.

[e] The collective population dose and health risk were determined for the entire shipment campaign; annual values can be calculated by dividing the collective risk by the duration of the shipment campaign (in years).

TABLE F.28 Inventory of Radionuclides in Each Container for Assessment of Maximally Exposed Individual and Population Accident Risk

Radionuclide	Container Inventory (mCi)	
	Maximally Exposed Individual[a]	Population[b]
Actinium-227	0.2	0.03
Lead-210	3.0	0.3
Protactinium-231	0.3	0.05
Radium-226	3.0	0.2
Radium-228	0.5	0.1
Thorium-230	5.2	0.2
Thorium-232	0.5	0.1
Uranium-235	0.3	0.06
Uranium-238	6.9	1.4

[a] A "worst-case" analysis that assumes the highest possible concentrations of radionuclides present in the waste.

[b] An analysis of the average risk for the entire shipment campaign that assumes waste containing concentrations of radionuclides averaged over all materials transported.

TABLE F.29 Radiological Impacts from Accidents Involving Transportation of Radioactive Material for Alternatives 7b and 7c

Alternative	Transport Mode	Route	Maximum Individual[a] Dose (mrem)	Maximum Individual[a] Risk
7b, 7c	Truck	Site to Wentzville	0.64	4×10^{-7}
7b	Rail	Wentzville to Clive	48	3×10^{-5}
7c	Rail	Wentzville to Hanford	48	3×10^{-5}

Alternative	Transport Mode	Route	Population[b] Dose (person-rem)	Population[b] Risk
7b, 7c	Truck	Site to Wentzville	0.0030	2×10^{-6}
7b	Rail	Wentzville to Clive	0.28	2×10^{-4}
7c	Rail	Wentzville to Hanford	0.41	2×10^{-4}

[a] The maximum dose and incremental risk to an individual assuming that an accident has occurred. The maximally exposed individual was assumed to reside 100 m from the accident site and consume only locally grown food for 1 year. Dose represents committed effective dose equivalent and includes contributions from inhalation, external gamma irradiation, and ingestion of contaminated food.

[b] The population dose and health risk are determined by multiplying the collective dose to the population following an accident by the probability of an accident occurring over the entire shipment campaign.

TABLE F.30 Summary Comparison of Potential Health Impacts Associated with the Final Remedial Action Alternatives

Receptor	Estimated Health Effect			
	Alternative 6a	Alternative 7a	Alternative 7b	Alternative 7c
General public in the vicinity of the Weldon Spring site				
Maximally exposed individual				
Radiological risk	6×10^{-7}	7×10^{-7}	7×10^{-7}	7×10^{-7}
Chemical carcinogenic risk	3×10^{-6}	3×10^{-6}	3×10^{-6}	3×10^{-6}
Chemical hazard index	0.0008	0.0008	0.0008	0.0008
Collective carcinogenic risk[a]				
Within 5 km of the site	3×10^{-3}	3×10^{-3}	3×10^{-3}	3×10^{-3}
Within 80 km of the site	2×10^{-2}	2×10^{-2}	2×10^{-2}	2×10^{-2}
Remedial action workers				
Maximally exposed individual[b]				
Radiological risk	1×10^{-3}	1×10^{-3}	1×10^{-3}	1×10^{-3}
Chemical carcinogenic risk	8×10^{-5}	8×10^{-5}	8×10^{-5}	8×10^{-5}
Chemical hazard index	10	10	10	10
Collective carcinogenic risk[a]	9×10^{-2}	2×10^{-1}	2×10^{-1}	2×10^{-1}
Persons along transport routes and transportation workers[a]				
Member of the general public				
Maximally exposed individual	NA[c]	NA	7×10^{-6}	7×10^{-6}
Collective carcinogenic risk	NA	NA	3×10^{-3}	3×10^{-3}
Transportation worker				
Maximally exposed individual	NA	NA	2×10^{-4}	2×10^{-4}
Collective carcinogenic risk	NA	NA	9×10^{-4}	9×10^{-4}
Remedial action workers and transportation workers				
Occupational fatalities	0.14	0.20	0.28	0.28
Occupational injuries	82	110	160	160

[a] Analysis was limited to radiological health impacts (see text).

[b] Health effect for a remedial action worker who participates in the project for the entire 7-year cleanup period.

[c] NA indicates that the entry is not applicable.

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APPENDIX G:

REGULATORY REQUIREMENTS POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE TO THE REMEDIAL ACTION

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G.1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has promulgated implementing regulations for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended; these regulations are presented in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA 1990). This plan identifies the remedial action process to be followed for sites on the National Priorities List (NPL), such as the Weldon Spring site. Included in the plan is a discussion of how regulatory requirements are to be addressed in evaluating alternatives for cleaning up a contaminated site and implementing the selected remedy.

The NCP specifies that the evaluation of alternatives for remedial action at an NPL site is to include an assessment of whether they will attain "applicable or relevant and appropriate requirements," referred to as ARARs; these requirements consist of federal and state environmental laws and state facility siting laws [Section 300.430(e)(9)(iii)(B)]. To be eligible for selection as the remedy for an NPL site, an alternative must attain ARARs unless a waiver is appropriate [Section 300.430(f)(1)(i)(A)]. Other advisories, criteria, or guidance developed by EPA, other federal agencies, or states that might be useful for developing the remedy for an NPL site can also be considered as part of the alternatives evaluation [Section 300.400(g)(3)]. These other measures are termed "to be considered" or TBC requirements.

Thus, potential requirements that are assessed as part of the evaluation of remedial action alternatives for an NPL site can be grouped into two general categories: ARARs and TBCs. The NCP indicates that the first category consists of standards promulgated in public laws codified at the federal or state level that might be applicable or relevant and appropriate to all or part of the action. Only those state laws may be considered ARARs that are (1) promulgated such that they are of general applicability and legally enforceable, (2) identified by the state in a timely manner, and (3) more stringent than federal requirements [Section 300.400(g)(4)]. The second category, TBCs, consists of standards or guidelines that have been published but not promulgated — such as U.S. Department of Energy (DOE) Orders or rules proposed by a state or federal government — that might be pertinent to the action being considered.

In addressing a requirement that may affect a remedial action being considered for a site, a determination is made regarding its relationship to (1) the location of the action, (2) the contaminants involved, and (3) the specific components of the action such as factors unique to a certain technology. Any regulation, standard, requirement, criterion, or limitation under any federal or state environmental law or state facility siting law may be either *applicable* or *relevant and appropriate* to a remedial action, but not both.

Applicable requirements are those that specifically address the circumstances at the site, whereas relevant and appropriate requirements are those that address circumstances sufficiently similar that they are well-suited to the site. That is, a potential ARAR is applicable if its prerequisites or regulated conditions are specifically met by the conditions of the action being evaluated — considering whether the requirement applies to a hazardous component, location, activity, or other circumstance of that remedial action. For example, certain contaminants are present in waste at the Weldon Spring site at levels that exceed those identified in tests for characteristic hazardous waste. This contaminant type is specifically regulated by certain requirements listed in the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendments; parallel requirements are identified in the Missouri Hazardous Waste Management Law and Regulations. If it were further determined that the activity being proposed for that waste was also specifically regulated by the given requirement — such as treatment or storage — the requirement could be considered applicable to that activity for that waste.

If the conditions of a requirement are not legally applicable to the remedial action at a site, then a determination must be made as to whether the requirement is both relevant *and* appropriate. For this determination, the requirement must be considered sufficiently similar to the circumstances of the action and it must also be well-suited to the site. This similarity is determined using best professional judgment, considering several factors identified by EPA in the NCP [Section 300.400(g)(2)]. These factors include (1) the purpose of the requirement and the purpose of the remedial action; (2) the medium, substance, action, type of place, and type and size of facility regulated or affected by the requirement relative to that affected at the site; and (3) the use or potential use of affected resources relative to the use of such resources at the site. The pertinence of these factors often depends on whether the requirement addresses a chemical, location, or action.

In accordance with EPA guidance on ARARs, only applicable requirements are evaluated for off-site actions, whereas both applicable and relevant and appropriate requirements are evaluated for on-site actions. On-site actions must comply with a requirement that is determined to be relevant and appropriate to the same extent as one that is determined to be applicable. However, a determination of relevance and appropriateness may be applied to only portions of a requirement, whereas a determination of applicability is made for the requirement as a whole. On-site actions must comply with substantive requirements of ARARs but not with related administrative and procedural requirements. For example, remedial actions conducted on-site would not require a permit but would be conducted in a manner consistent with the permitted conditions.

To simplify the discussions in the documents for the current remedial action at the Weldon Spring site, the term "on-site" has been used to refer to the property located within the fence of the chemical plant area and the term "off-site" to refer to contaminated locations outside the fence. The formal definition of the term "site" in the context of this remedial action includes the chemical plant area, related soil vicinity properties, and other areas contaminated by the migration of a hazardous substance, pollutant, or contaminant from any of the properties under the custody and accountability of DOE. The application of specific environmental regulations

to activities being considered for off-site facilities, such as treatment of liquid waste at an off-site incinerator or disposal of waste at the Envirocare or Hanford site, would be addressed by the respective owners/operators in the environmental compliance documents and activities for those facilities.

Potential TBC requirements are typically considered only if no promulgated requirements exist that are either applicable or relevant and appropriate. Thus, TBC requirements may be considered secondary to ARARs; in fact, certain of these requirements (e.g., DOE Orders) are often developed on the basis of promulgated standards and can necessitate the same degree of compliance as ARARs. Because the Weldon Spring site is a DOE facility, applicable DOE Orders will be followed irrespective of their "TBC" designation under the ARARs process. Potential ARARs and TBC requirements for the final alternatives being considered for the current remedial action at the Weldon Spring site are identified and evaluated in Section G.2.

After the remedial action alternatives have been evaluated and public comments have been received on the environmental documents prepared for a given cleanup action proposed for an NPL site, a remedy is selected and documented in the record of decision for that action. This record of decision includes a discussion of ARARs, and those requirements identified in the record as applicable or relevant and appropriate for the selected action are to be met upon its completion and also during the course of the remedial design and remedial action period, unless the conditions of appropriate waivers are met [Section 300.435(b)(2) of the NCP].

In the NCP, EPA identifies six circumstances under which an alternative for remedial action may be selected without meeting an ARAR [Section 300.430(f)(1)(ii)(C)]. These are:

1. The alternative is an interim measure and will become part of a total remedial action that will attain the requirement;

2. Compliance with the requirement will result in greater risk to human health and the environment than other alternatives;

3. Compliance with the requirement is technically impracticable from an engineering perspective;

4. The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach;

5. With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state; or

6. For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies

to respond to other sites that may present a threat to human health and the environment. (The Weldon Spring site is not being cleaned up with Superfund money, so this last waiver condition does not apply to the project.)

Each of the final action alternatives being considered for the Weldon Spring site would attain ARARs during the cleanup period and upon completion unless one of these waiver conditions was met. The first waiver condition could apply to certain activities that would be conducted during site cleanup. For example, waste handling activities such as loading quarry material from the temporary storage area for transport to a treatment facility might increase radon concentrations at the fence line adjacent to that area for limited periods, to levels that exceed the standard given in the Missouri Radiation Regulations. However, this standard would be met upon completion of those activities and also upon completion of the remedial action as a whole. In addition, the requirement specifically applies to areas at which public access is uncontrolled, and it is likely that the increase would occur at the boundary that abuts the Army property to the west, to which access is controlled. Similarly, the fourth waiver condition could apply to physical systems such as a newly constructed facility for which an engineered equivalent was determined to be appropriate for achieving the performance measure indicated in a given requirement. The few waivers being considered for the final action alternatives at the Weldon Spring site are discussed in Section 7.1.2 and in the respective sections for each alternative in Chapter 6. A more detailed discussion of ARARs will be presented in the record of decision for this action.

G.2 PRELIMINARY EVALUATION OF REQUIREMENTS

Requirements of federal and state laws that might be considered applicable or relevant and appropriate to the proposed remedial action at the chemical plant area of the Weldon Spring site are listed in Table G.1 (location-specific requirements), Table G.2 (contaminant-specific requirements), and Table G.3 (action-specific requirements); potential TBC requirements are also included in the tables. In addition, the tables include certain requirements that are part of an employee protection law or some other non-environmental law with which CERCLA actions must comply, and which are therefore not subject to the ARAR evaluation process for attainment or waiver; these requirements have simply been included to identify those standards with which the remedial action would comply to ensure overall protectiveness, e.g., for workers.

Many requirements could have been listed in more than one table, but they are shown in only one to limit redundancy. For example, standards for radon emissions could have been presented with both contaminant-specific and action-specific requirements; they are listed with the former. Similarly, siting criteria for hazardous waste facilities could have been presented with both location-specific and action-specific requirements; they are listed with the latter.

The preliminary ARAR and TBC determinations for these requirements are also indicated on the tables. Because this appendix presents a comprehensive list of requirements with considerable overlap of regulated conditions, all determinations have been identified as "potentially" applicable, relevant and appropriate, or to be considered. These determinations will

be finalized in consultation with the state of Missouri and EPA Region VII prior to implementing the selected remedial action. During the finalization process, the requirements identified as potentially applicable will be reviewed to confirm direct applicability; only one requirement will be finalized from among those that regulate the same conditions. For those identified as potentially relevant and appropriate and TBC requirements, the specific portion(s) of the requirements that have bearing on the action, and the manner in which compliance would be achieved, will be finalized. After the finalization process, certain of the requirements will remain potentially an ARAR or a TBC requirement as the cleanup action proceeds, pending identification of the existence of the prerequisites or regulated conditions, such as the presence of cultural resources or threatened or endangered species in the affected areas.

A decision for surface water at the site is beyond the scope of the current remedial action because it was previously addressed as part of an interim action. That is, the engineering evaluation/cost analysis report for contaminated surface water at the site included consideration of water in existing impoundments as well as water that would be generated and collected as part of the remedial action currently being evaluated (MacDonell et al. 1990). Therefore, related ARARs and TBCs have been previously determined and, in general, are not repeated in this table. With regard to off-site surface water in the Busch Wildlife Area lakes, the water will be drained within the next few years under a separate action by the Missouri Department of Conservation as part of the routine sedimentation management program for lakes in the wildlife area. This water is not used as a drinking water supply, so related ARARs and TBCs do not apply; water quality standards developed for protection of human health (e.g., from fish consumption) are not exceeded by contaminants directly attributed to the site. Those standards developed for ecological receptors are discussed in Chapter 7 of the baseline assessment (BA) for the chemical plant area (DOE 1992a).

Similarly, a decision for groundwater is beyond the scope of the current remedial action; it is being addressed as a future operable unit of the site's comprehensive cleanup. Therefore, related ARARs and TBCs are not included in the following tables; they will be identified and evaluated in the remedial investigation/feasibility study (RI/FS) for the groundwater operable unit that will be prepared within the next several years. However, a limited discussion of pertinent groundwater standards is presented in Appendix B of the BA (DOE 1992a) to provide a basis for comparison with current information on groundwater contamination at the site.

Although the final ARAR determinations will be documented in the forthcoming record of decision for the current remedial action, determinations have been proposed for key requirements on the basis of the preliminary analyses in Tables G.1 through G.3. These determinations are presented in Chapter 6 (in the ARARs subsection for each alternative) and Chapter 7 (Section 7.1.2) of this FS and also in the proposed plan (DOE 1992b).

TABLE G.1 Potential Location-Specific Requirements[a]

Citation	Location	Requirement	Preliminary Determination	Remarks
Antiquities Act; Historic Sites Act (16 USC 431-433; 16 USC 461-467)	Land	Cultural resources on federal land, such as historic buildings and sites and natural landmarks, should be preserved and adverse impacts avoided.	Potentially applicable	No adverse impacts to such resources are expected to result from the remedial action; however, if these resources were affected, the requirement would be applicable.
National Historic Preservation Act, as amended (16 USC 470 et seq.; 36 CFR 800)	Land	The effect of any federally assisted undertaking should be taken into account for any district, site, building, structure, or object included in or eligible for the *National Register of Historic Places*.	Potentially applicable	No adverse impacts to such properties are expected to result from the remedial action; however, if these resources were affected, the requirement would be applicable.
Executive Order 11593 (Protection and Enhancement of the Cultural Environment)	Land	Federal agencies should inventory historic properties on their lands and nominate eligible properties to the *National Register*.	Potentially applicable	No impacts to such resources are expected to result from the remedial action. The site has been considerably disturbed by past human activities and is therefore not expected to contain such resources. However, if these resources were affected, e.g., at the potential off-site borrow area, the requirements would be applicable.
Archeological and Historic Preservation Act (16 USC 469; PL 93-291; 88 Stat. 174)	Land	Data recovery and preservation activities should be conducted if prehistoric, historical, and archaeological data might be destroyed as a result of a federal, federally assisted, or federally licensed activity or program.	Potentially applicable	No destruction of such data is expected to result from the remedial action. The site has been considerably disturbed by past human activities and is therefore not expected to contain any such data. However, if these data were affected, e.g., at the potential off-site borrow area, the requirement would be applicable.
Archeological Resources Protection Act [16 USC 470(a)]	Land	A permit should be obtained from the federal land manager for excavation or removal of any archaeological resources on federal lands.	Potentially applicable	No impacts to archaeological resources are expected to result from the remedial action. The site has been considerably disturbed by past human activities and is therefore not expected to contain such resources. However, if these resources were affected, e.g., at the potential off-site borrow area, the requirement would be applicable.

TABLE G.1 (Cont.)

Citation	Location	Requirement	Preliminary Determination	Remarks
Endangered Species Act, as amended [16 USC 1531-1543; 50 CFR 17.402; 40 CFR 6.302(h)]	Any	Federal agencies should ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify any critical habitat.	Potentially applicable	No critical habitat has been identified in the affected area, and no adverse impacts to threatened or endangered species are expected to result from the remedial action; however, if such species were affected, the requirement would be applicable. A biological assessment has been prepared for the current remedial action to evaluate the potential for adverse impacts to federal listed and proposed threatened and endangered species and their habitats (Appendix I). This assessment has been submitted to offices of the U.S. Fish and Wildlife Service.
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.111), Endangered Species	Any	Endangered species, i.e., those designated by the U.S. Department of the Interior and the Missouri Department of Conservation as threatened or endangered (see 1978 Code, RSMo. 252.240), should not be pursued, taken, possessed, or killed.	Potentially applicable	No critical habitat has been identified in the affected area, and no adverse impacts to threatened or endangered species are expected to result from the remedial action. However, if such species were affected, the requirement would be applicable.
Missouri Wildlife Code (1978) (RSMo. 252.240), Endangered species importation, transportation or sale, when prohibited — how designated — penalty	Any	The Missouri Department of Conservation should file with the state a list of animal species designated as endangered (for subsequent consideration of related requirements).	Potentially applicable	No critical habitat has been identified in the affected area, and no adverse impacts to threatened or endangered species are expected to result from the remedial action. However, if such species were affected, the requirement would be applicable.
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.110), General Prohibition; Applications	Any	Wildlife, including their homes and eggs, should not be taken, molested, hunted, trapped, killed, or transported except under permitted conditions.	Potentially relevant and appropriate	No wildlife would be actively taken, molested, hunted, trapped, killed, or transported as part of the remedial action. Mitigative measures would be taken to minimize potential environmental impacts, including those to wildlife.

TABLE G.1 (Cont.)

Citation	Location	Requirement	Preliminary Determination	Remarks
Missouri Wildlife Code (1989) (RSMo. 252.240; 3 CSR 10-4.115), Special Management Areas	Any	Wildlife should not be taken, pursued, or molested on any state or federal wildlife refuge or any wildlife management area, except under permitted conditions.	Potentially relevant and appropriate	No wildlife would be actively taken, pursued, or molested in any wildlife areas as part of the remedial action. Mitigative measures would be taken to minimize potential environmental impacts, including those to wildlife.
Fish and Wildlife Coordination Act [14 USC 441-444; 40 CFR 4.302(a)]	Stream or other water body or affecting area	Adequate protection of fish and wildlife resources is required when any federal department or agency proposes or authorizes any modification (e.g., diversion or channeling) of any stream or other water body or any modification of areas affecting any stream or other water body.	Not an ARAR	No modification of streams or stream areas is planned as part of the current remedial action.
Missouri Wildlife Code (1978) (RSMo.252.210; 3 CSR 10-4.110), General Prohibition; Contamination of streams	Stream	It is unlawful to put any deleterious substances into waters of the state in quantities sufficient to injure fish, except under precautionary measures approved by the state.	Not an ARAR	No such discharge is planned as part of the current remedial action.
Floodplain Management [Executive Order 11988; 40 CFR 6.302(b)]	Floodplain	Federal agencies should avoid, to the maximum extent possible, any adverse impacts associated with direct and indirect development of a floodplain.	Potentially applicable	This requirement would be applicable to the remedial action for the small portion of the Schote Creek floodplain in the Ash Pond drainage at the northern portion of the site and an adjacent vicinity property extending a short distance off-site. Mitigative measures would be taken to minimize any adverse impacts, and the areas would be restored to original conditions upon completion of the remedial action. A floodplain assessment has been prepared for this action (presented together with the wetland assessment in Appendix H).

TABLE G.1 (Cont.)

Citation	Location	Requirement	Preliminary Determination	Remarks
Governor's Executive Order 82-19	Floodplain	Potential effects of actions taken in a floodplain should be evaluated to avoid adverse impacts.	Potentially applicable	This requirement would be applicable to the remedial action for the small portion of the Schote Creek floodplain in the Ash Pond drainage at the northern portion of the site and an adjacent vicinity property extending a short distance off-site. Mitigative measures would be taken to minimize any adverse impacts, and the areas would be restored to original conditions upon completion of the remedial action.
Clean Water Act (33 USC 1251-1376); Disposal Sites, Specifications (40 CFR 230), Dredged or Fill Material Discharges (Section 404 Program); Definitions, Exempt Activities Not Requiring Permits (40 CFR 232); State Program Regulations (40 CFR 233); General Regulatory Policies (33 CFR 320); Nationwide Permits (33 CFR 330)	Wetland	Dredge or fill material is not to be discharged into a wetland (as defined by the U.S. Army Corps of Engineers) without a permit.	Potentially applicable/ not an ARAR	This requirement would be applicable to the off-site borrow area if the location selected contained any wetlands (as does the representative borrow area currently being evaluated) or if the borrow activities could indirectly impact wetlands. For the on-site wetlands, the U.S. Army Corps of Engineers has determined that no permit is required for related activities because the wetlands are within the boundaries of an NPL site and are therefore exempt from this administrative requirement.
Protection of Wetlands [Executive Order 11990; 40 CFR 6.302(a)]	Wetland	Federal agencies should avoid, to the extent possible, any adverse impacts associated with the destruction or loss of wetlands and the support of new construction in wetlands if a practicable alternative exists.	Potentially applicable	The requirement would be applicable to the management of sludge and sediment remaining in the on-site impoundments that have been classified as wetlands. (Surface water has been addressed under an earlier action.) As previously determined, no practicable alternative exists for these areas but to remove and treat the contaminated material. If wetlands are present or could be impacted by activities in the off-site borrow area selected for this action, this requirement would also be applicable at that area. Mitigative measures such as wetland replacement are being coordinated with the state of Missouri. A wetland assessment has been prepared for this action (presented together with the floodplain assessment in Appendix H).

TABLE G.1 (Cont.)

Citation	Location	Requirement	Preliminary Determination	Remarks
Farmland Protection Policy Act (7 USC 4201 et seq.) Farmland Protection [7 CFR 658; 40 CFR 6.302(c)]	Farmland (prime, unique, or of state and local importance)	Federal agencies should take steps to ensure that federal actions do not cause U.S. farmland to be irreversibly converted to nonagricultural uses in cases in which other national interests do not override the importance of the protection of farmland or otherwise outweigh the benefits of maintaining farmland resources. Criteria developed by the U.S. Soil Conservation Service are to be used to identify and take into account the adverse effects of federal programs on farmland preservation. Federal agencies should consider alternative actions that could lessen adverse effects and should ensure that programs are compatible with state and local government and private programs and policies to protect farmland.	Potentially applicable	This requirement would be applicable for some on-site areas and the potential soil borrow area off-site. On-site areas have been disturbed and contaminated by past activities, and the site would be restored following cleanup to support other uses (such as farmland) to the extent practicable, within the constraints of the final site decision. Mitigative measures and restoration activities would also be conducted at the off-site borrow area, as appropriate, to minimize any adverse impacts to farmland.

▲ Potential facility siting requirements are identified in Table G.3 with the action-specific ARARs for facility construction.

TABLE G.2 Potential Contaminant-Specific Requirements

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart D, Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended; Subpart E, Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended	Radiation	Any	Processing operations during and prior to the end of the closure period at a facility managing uranium and thorium by-product materials should be conducted in a manner that provides reasonable assurance that the annual dose equivalent does not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public as a result of exposures to the planned discharge of radioactive material to the general environment (excluding radon-222, radon-220, and their decay products).	Potentially relevant and appropriate	These requirements would not be applicable because the remedial action does not constitute a processing operation, nor does it include a planned discharge of radioactive material to the environment. Nevertheless, the requirements could be considered relevant and appropriate to protection of the public during implementation of the action because the waste type and the potential release issue could be considered sufficiently similar.
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Radiation	Any	The basic dose limit for nonoccupationally exposed individuals is 100 mrem/yr above background, effective dose equivalent. Also, all radiation exposures should be reduced to levels as low as reasonably achievable.	To be considered	Although not promulgated standards, these requirements are derived from such standards and constitute requirements for protection of the public with which the action would comply.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	Radiation	Any	For persons outside a controlled area, the maximum permissible whole-body dose due to sources in or migrating from the controlled area is limited to 2 mrem in any 1 hour, 0.1 rem in any 7 consecutive days, and 0.5 rem in any 1 year. (Note: a controlled area is an area that requires control of access, occupancy, and working conditions for radiation protection purposes; 0.5 rem = 500 mrem.)	Potentially applicable	These requirements would be applicable to protection of the public during implementation of the action.
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Radiation	Any	The concentrations of radionuclides in liquid wastes discharged to natural waterways should be reduced to levels ensuring that the absorbed dose to native aquatic animal organisms does not exceed 1 rad/d.	To be considered	Although not a promulgated standard, this requirement provides protection for aquatic organisms from liquid discharges with which the remedial action would comply.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Radiation Protection for Occupational Workers (DOE Order 5480.11)	Radiation	Any	The effective dose equivalent received by any member of the public entering a controlled area is limited to 100 mrem/yr. Limiting values for the assessed dose from exposure of workers to radiation are as follows:	To be considered	Although not promulgated standards, these constitute requirements for protection from radiation exposures in a controlled area with which the remedial action would comply.

Radiation Effect	Annual Dose Equivalent (rem)
Stochastic effects	5[a]
Nonstochastic effects	
Lens of eye	15
Organ, extremity, or tissue including skin of whole body	50
Unborn child, entire gestation period	0.5

[a] Annual effective dose equivalent.

These values represent maximum limits; it is DOE policy to maintain radiation exposures as far below these limits as is reasonably achievable.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.96), Subpart G, Ionizing Radiation	Radiation	Any	The dose per calendar quarter resulting from exposure to radiation in a restricted area from sources in that area is limited to the following: Part of Body — Dose (rem) Whole body, head and trunk, active blood-forming organs, lens of eye, or gonads — 1¼ Hands and forearms, feet and ankles — 18¾ Skin of whole body — 7½ The occupational exposure of an individual younger than 18 is restricted to 10% of these limits; the whole-body dose to a worker may not exceed 3 rem in a calendar quarter and, when added to the cumulative occupational dose, should not exceed 5(N-18) rem, where N is the age of the exposed individual.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply. Therefore, these requirements are not subject to the ARAR evaluation process for attainment or waiver. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	Radiation	Any	Limits for occupational doses from ionizing radiation in a controlled area are as follows: Part of Body / Maximum Dose in Any Calendar Year (rem) / Maximum Dose in Any Calendar Quarter (rem) Whole body, head and trunk, major portion of bone marrow, gonads, or lens of eye: 5 / 3 Hands and forearms, feet and ankles: 75 / 25 Skin of large body area: 30 / 10 Also, the whole-body dose added to the cumulative occupational dose should not exceed 5(N-18) rem, where N is the age of the exposed individual.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.050), Personnel Monitoring and Radiation Surveys	Radiation	Any	Personnel monitoring and radiation surveys are required for each worker for whom there is any reasonable possibility of receiving a weekly dose from all radiation exceeding 50 mrem, taking into consideration the use of protective gloves and radiation-limiting devices. An exemption from routine monitoring may be granted under certain conditions.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities	Radionuclides other than radon-220 and radon-222	Air	Emissions of such radionuclides to the ambient air from DOE facilities should not result in an effective dose equivalent of >10 mrem/yr to any member of the public.	Potentially applicable	These requirements would be applicable to protection of the public during implementation of the remedial action because the Weldon Spring site is a DOE facility.
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart Q, National Emission Standards for Radon Emissions from Department of Energy Facilities	Radon-222	Air	No source at a DOE facility should emit more than 20 pCi/m^2-s of radon-222 as an average for the entire source. (As for several other requirements, this entry could also have been listed in Table G.3 because it pertains to specific actions — in this case, storage and disposal.) The provisions of this subpart apply to the design and operation of all storage and disposal facilities for radium-containing material (i.e., by-product material as defined under Section 11e(2) of the Atomic Energy Act, as amended) that are owned or operated by DOE, except those facilities designated under Title I of the Uranium Mill Tailings Radiation Control Act.	Potentially applicable	These requirements would be applicable to protection of the public during implementation of the remedial action because the Weldon Spring site is a DOE facility that is not designated for exception as a mill tailings facility under the listed act.
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart T, National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings	Radon-222	Air	Radon-222 emissions to ambient air from uranium mill tailings piles that are no longer operational should not exceed 20 pCi/m^2-s.	Potentially relevant and appropriate	The Weldon Spring site is not a designated uranium mill tailings site, so this requirement would not be applicable; however, it could be considered relevant and appropriate because the site contains material sufficiently similar to uranium mill tailings and the potential release issue could be well suited to final site conditions.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart A, Standards for the Control of Residual Radioactive Material from Inactive Uranium Processing Sites	Radon-222	Air	The annual average release rate of radon-222 to the atmosphere applied over the entire surface of a disposal site should not exceed 20 pCi/m^2-s, and the annual average concentration of radon-222 in air at or above any location outside the disposal site should not be increased by more than 0.5 pCi/L.	Potentially relevant and appropriate	The Weldon Spring site is not a designated uranium processing site, so these requirements would not be applicable; however, they could be considered relevant and appropriate because the site contains material sufficiently similar to uranium mill tailings and the potential release issue could be well suited to final site conditions.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart B, Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites	External gamma radiation	Air	The level of external gamma radiation in any occupied or habitable building should not exceed the background level by more than 20 μR/h.	Not an ARAR	The Weldon Spring site is not a designated uranium processing site, so these requirements would not be applicable; neither would they be relevant and appropriate because no habitable buildings would be involved in the remedial action.
	Radon-222 decay products	Air	The annual average (or equivalent) radon decay product concentration, including background, in any habitable building should not exceed 0.02 working level (WL) and, in any case, should not exceed 0.03 WL — where a WL is any combination of short-lived radon decay products in 1 liter of air, without regard to the degree of equilibrium, that will result in the emission of 1.3×10^5 MeV of alpha energy. (Note that 1 WL = 100 pCi/L for radon-222 in equilibrium with its decay products.)	Not an ARAR	The Weldon Spring site is not a designated uranium processing site, so these requirements would not be applicable; neither would they be relevant and appropriate because no habitable buildings would be involved in the remedial action.
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	External gamma radiation	Air	The level of external gamma radiation in any occupied or habitable building should not exceed the background level by more than 20 μR/h.	Not a TBC	These would be addressed as "to be considered" requirements because they are not promulgated standards; however, they would not be pertinent to the remedial action because no habitable buildings would be involved.
	Radon-222	Air	Releases of radon-222 from residual radioactive material disposal sites should not exceed an annual average release rate of 20 pCi/m^2-s or increase the annual average radon-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L.	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action would comply.
	Radon-222 and radon-220	Air	The above-background concentration of radon-222 in air above an interim storage facility should not exceed 100 pCi/L at any point, an annual average of 30 pCi/L over the site, or an annual average of 3 pCi/L at or above any location outside the site. The derived concentration guide for immersion in air in an uncontrolled area for both radon-220 and radon-222 is 3 pCi/L. (See also the discussion for DOE Order 5820.2A in Table G.3.)	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action would comply.
	Radon-222 decay products	Air	The annual average (or equivalent) radon decay product concentration, including background, in any habitable building should not exceed 0.02 WL and, in any case, should not exceed 0.03 WL.	Not a TBC	These would be addressed as "to be considered" requirements because they are not promulgated standards; however, they would not be pertinent to the remedial action because no habitable buildings would be involved.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Specific radionuclides (see table)	Air	Residual concentrations of radionuclides in air in uncontrolled areas are limited to the following:	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action would comply.

Isotope	Derived Concentration Guides[a] (μCi/mL) D	W	Y
Actinium-227	2×10^{-15}	7×10^{-15}	1×10^{-14}
Lead-210	9×10^{-13}	-[b]	-
Protactinium-231	-	9×10^{-15}	1×10^{-14}
Radium-226	-	1×10^{-12}	-
Radium-228	-	3×10^{-12}	-
Radon-222	3×10^{-9}	-	-
Thorium-230	-	4×10^{-14}	5×10^{-14}
Thorium-232	-	7×10^{-15}	1×10^{-14}
Uranium-235	5×10^{-12}	2×10^{-12}	1×10^{-13}
Uranium-238	5×10^{-12}	2×10^{-12}	1×10^{-13}

[a] D, W, and Y represent lung retention classes; removal half-times assigned to the compounds in classes D, W, and Y are 0.5, 50, and 500 days, respectively. Exposure conditions assume an inhalation rate of 8,400 m^3 of air per year (based on an exposure over 24 hours per day, 365 days per year).

[b] A hyphen means no limit has been established.

For known mixtures of radionuclides, the sum of the ratios of the observed concentration of each radionuclide to its corresponding limit should not exceed 1.0.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040), Maximum Permissible Exposure Limits	Specific radionuclides (see table)	Air	The concentrations above natural background of radionuclides in air outside a controlled area, averaged over any calendar quarter, should not exceed the following limits:	Potentially applicable	These requirements would be applicable to protection of the public during implementation of the remedial action. A waiver could be pertinent for the radon-222 limit during the cleanup period because of quarry bulk waste activities at the temporary storage area (TSA). This facility is close to the fence line that separates the site from the adjacent Army property, at which location a short-term exceedance might occur during implementation. The waiver would be appropriate because of the intermediate nature of the action, which would be part of an overall action that would attain compliance upon completion.

Isotope	Concentration Limit (μCi/mL) Soluble	Insoluble
Actinium-227	8×10^{-14}	9×10^{-13}
Lead-210	4×10^{-12}	8×10^{-12}
Protactinium-231	4×10^{-14}	4×10^{-13}
Radium-226	1×10^{-12}	6×10^{-9}
Radium-228	2×10^{-12}	1×10^{-12}
Radon-222	1×10^{-9}	NA[a]
Thorium-230	8×10^{-14}	3×10^{-13}
Thorium-232	7×10^{-14}	4×10^{-13}
Uranium-235	2×10^{-13}	4×10^{-12}
Uranium-238	3×10^{-12}	5×10^{-12}

[a] Not applicable because radon-222 is a gas.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910; 1910.96), Subpart G, Ionizing Radiation	Specific radionuclides (see table)	Air	Occupational exposure to airborne radioactive material should not exceed the following concentrations, averaged over a 40-hour work week of seven consecutive days:	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.

Isotope	Concentration Limit (μCi/mL) Soluble	Insoluble
Actinium-227	2×10^{-12}	3×10^{-11}
Lead-210	1×10^{-10}	2×10^{-10}
Protactinium-231	1×10^{-12}	1×10^{-10}
Radium-226	3×10^{-11}	5×10^{-13}
Radium-228	7×10^{-11}	4×10^{-11}
Radon-222[a]	3×10^{-9}	NA[b]
Thorium-230	2×10^{-12}	1×10^{-11}
Thorium-232	3×10^{-11}	3×10^{-11}
Uranium-235	5×10^{-10}	1×10^{-10}
Uranium-238	7×10^{-11}	1×10^{-10}

[a] Limit is appropriate for radon-222 combined with its short-lived decay products and may be replaced by 1/3 WL; the limit in restricted areas may be based on an annual average.

[b] Not applicable because radon-222 is a gas.

For mixtures of radionuclides, the sum of the ratios of the quantity present to the specific limit should not exceed 1. For uranium, chemical toxicity may be the limiting factor for soluble mixtures of uranium in air; if the percent by weight of uranium-235 is less than 5, the concentration limit for total uranium is 0.2 mg/m^3 inhaled air. For hours of exposure less than or greater than 40, the limits are proportionately increased or decreased, respectively.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Radiation Protection for Occupational Workers (DOE Order 5480.11)	Specific radionuclides (see table)	Air	Occupational exposure to airborne radioactive material should not exceed the following concentrations on an annual average:	Not a TBC	These would be "to be considered" requirements because they are not promulgated; however, they address employee protection (rather than environmental protection) with which CERCLA response actions should comply, and so they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.

	Derived Air Concentration[a] (μCi/mL)		
Isotope	D	W	Y
Actinium-227	2×10^{-13}	7×10^{-13}	2×10^{-12}
Lead-210	1×10^{-10}	-[b]	-
Protactinium-231	-	7×10^{-12}	2×10^{-12}
Radium-226	-	3×10^{-10}	-
Radium-228	-	5×10^{-10}	-
Radon-222[c]	3×10^{-6}	-	-
Thorium-230	-	3×10^{-12}	7×10^{-12}
Thorium-232	-	5×10^{-13}	1×10^{-12}
Uranium-235	6×10^{-10}	3×10^{-10}	2×10^{-11}
Uranium-238	6×10^{-10}	3×10^{-10}	2×10^{-11}

[a] D, W, and Y represent lung retention classes; removal half-times assigned to the compounds in classes D, W, and Y are 0.5, 50, and 500 days, respectively. Exposure conditions assume an inhalation rate of 2,400 m^3 of air per year (based on an exposure over 40 hours per week, 50 weeks per year).

[b] A hyphen means no limit has been established.

[c] The value for radon-222 assumes 100% equilibrium with its short-lived decay products; this value may be replaced by 1/3 WL.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.040); Maximum Permissible Exposure Limits	Specific radionuclides (see table)	Air	Occupational exposure to airborne radioactive material, averaged over any calendar quarter, should not exceed the following limits:	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.

Isotope	Concentration Limit (μCi/mL) Soluble	Insoluble
Actinium-227	2×10^{-12}	3×10^{-11}
Lead-210	1×10^{-10}	2×10^{-10}
Protactinium-231	1×10^{-12}	1×10^{-10}
Radium-226	3×10^{-11}	2×10^{-7}
Radium-228	7×10^{-11}	4×10^{-11}
Radon-222	3×10^{-6}	NA[a]
Thorium-230	2×10^{-12}	1×10^{-11}
Thorium-232	2×10^{-12}	1×10^{-10}
Uranium-235	5×10^{-10}	1×10^{-10}
Uranium-238	7×10^{-11}	1×10^{-10}

[a] Not applicable because radon-222 is a gas.

Limits apply to occupational exposure in a controlled area and are based on a work week of 40 hours; for longer work weeks, the values must be adjusted downward.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Occupational Safety and Health Administration Standards (29 CFR 1910; 1910.1000), Subpart Z, Toxic and Hazardous Substances	Specific organic and inorganic substances	Air	Permissible occupational exposure limits for various airborne substances have recently been revised to the following final rule limits; they may be achieved by any reasonable combination of engineering controls, work practices, and personal protective equipment:	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.

Parameter[a]	Limit[b] (mg/m^3)	Condition
Aluminum	15	For total dust, as aluminum metal; limit for respirable dust and for welding fumes (determined from breathing-zone air samples) is 5 mg/m^3; limit for soluble salts is 2 mg/m^3.
Antimony	0.5	Antimony and compounds, as antimony.
Arsenic	0.01	Inorganic compounds, as arsenic.
Barium	0.5	Soluble compounds, as barium.
Beryllium	0.002	Beryllium and compounds, as beryllium.
Cadmium	0.005	All cadmium compounds, including dust and fumes.
Carbon	40	The ceiling is 229 mg/m^3. (Measured in ppm, the limit is 35 and the ceiling is 200.)
Chromium	1	As chromium metal; limit for chromium II and III compounds, as chromium, is 0.5 mg/m^3.
Copper	1	For dusts and mists, as copper; limit for fume, as copper, is 0.1 mg/m^3.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement			Preliminary Determination	Remarks
			Parameter[a]	Limit[b] (mg/m³)	Condition		
(Cont.)			Fluorides	2.5	As fluorine.		
			Iron	10	For iron oxide fume (in ppm), as the short-term (15-minute) limit.		
			Lead	0.05	For metallic lead and inorganic compounds, as lead.		
			Lithium	0.025	Lithium, as lithium hydride.		
			Manganese	1	For fume, as manganese; the limit for short-term (15-minute) exposure is 3 mg/m³, and the ceiling for manganese compounds, as manganese, is 5 mg/m³.		
			Mercury	0.05	Mercury vapor, as mercury.		
			Molybdenum	5	For soluble compounds, as molybdenum; limits for insoluble compounds are 10 mg/m³ for total dust and 5 mg/m³ for the respirable fraction.		
			Nickel	0.1	For soluble compounds, as nickel; limit for metallic nickel and insoluble compounds, as nickel, is 1 mg/m³.		
			Selenium	0.2	For selenium compounds, as selenium.		
			Silver	0.01	For metal and soluble compounds, as silver.		

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement			Preliminary Determination	Remarks
(Cont.)			Parameter[a]	Limit[b] (mg/m^3)	Condition		
			Thallium	0.1	For soluble compounds, as thallium.[c]		
			Uranium	0.05	For soluble compounds, as uranium; limit for insoluble compounds, as uranium, is 0.2 mg/m^3, with a short-term (15-minute) exposure limit of 0.6 mg/m^3.		
			Vanadium	0.05	Respirable dust, as vanadium oxide (V_2O_5).		
			Zinc	10	For zinc oxide dust (total); limit for respirable dust is 5 mg/m^3; limit for zinc oxide fume is 5 mg/m^3, and the short-term (15-minute) exposure limit is 10 mg/m^3.		
			Particulates:		For particulates not otherwise regulated (i.e., nuisance dust).		
			Total dust	15			
			Respirable fraction	5			
			Welding fumes	5	As total particulates, determined from breathing-zone air samples.		
			DNB	1	For all DNB isomers.[c]		
			2,4-DNT	1.5	For total DNT; isomer unspecified.[c]		

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement			Preliminary Determination	Remarks
(Cont.)			Parameter[a]	Limit[b] (mg/m^3)	Condition		
			2,6-DNT	1.5	For total DNT; isomer unspecified.[c]		
			NB	5	See footnote c.		
			TNB	0.5	See footnote c.		
			TNT	0.5	See footnote c.		
			PAHs[d]	0.2	For coal tar pitch volatiles, measured as the benzene-soluble fraction of total particulate matter.		
			PCBs[e]	0.5	For chlorodiphenyl (54% chlorine).[c]		

[a] Notation: DNB, dinitrobenzene; 2,4-DNT, 2,4-dinitrotoluene; 2,6-DNT, 2,6-dinitrotoluene; NB, nitrobenzene; TNB, trinitrobenzene; TNT, trinitrotoluene; PAHs, polycyclic aromatic hydrocarbons; PCBs, polychlorinated biphenyls.

[b] Permissible exposure limit (PEL) expressed as the 8-hour time-weighted average, except as noted. The PEL listed for cadmium was recently finalized, and the standard takes effect December 14, 1992.

[c] Skin absorption to be reduced (e.g., with protective clothing) to limit overall exposure via the cutaneous route (airborne or direct contact).

[d] Benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene.

[e] Aroclor 1248, 1254, and 1260.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Clean Air Act, as amended (42 USC 7401-7642); National Primary and Secondary Ambient Air Quality Standards (40 CFR 50), Subchapter C — Air Programs	Particulate matter, lead, carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone	Air	Concentrations are limited as identified below. Primary standards address protection of public health, and secondary standards address protection of public welfare. Where available, secondary standards are the same as the primary standards, except as noted.	Not an ARAR	These requirements would not be ARARs because they do not apply directly to source-specific emissions; rather, they are national limitations on ambient concentrations. However, they would be addressed in controlling emissions of these contaminants that could result from implementation of the remedial action.

Contaminant	Concentration	Condition
Particulate matter ≤10 µm in diameter (PM-10)	50 µg/m³	Annual arithmetic mean.
	150 µg/m³	24-hour average concentration.
Lead	1.5 µg/m³	Arithmetic mean averaged over a calendar quarter.
Carbon monoxide	10 mg/m³	8-hour average not to be exceeded more than once per year (primary standard).
	40 mg/m³	1-hour average not to be exceeded more than once per year (primary standard).
Sulfur dioxide	80 µg/m³	Annual arithmetic mean (primary standard).
	365 µg/m³	24-hour average not to be exceeded more than once per year (primary standard).
	1,300 µg/m³	3-hour average not to be exceeded more than once per year (secondary standard).
Nitrogen dioxide	100 µg/m³	Annual arithmetic mean.
Ozone	235 µg/m³	1-hour average not to be exceeded more than one day per year.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Missouri Air Conservation Law; Public Health and Welfare (RSMo. Title 12, 643.055). Commission may adopt rules for compliance with federal law — suspension, reinstatement	Any regulated under federal Clean Air Act	Air	Standards and guidelines promulgated to ensure that Missouri is in compliance with the Clean Air Act are not to be any stricter than those required under that act (see related discussion of 40 CFR 50).	Not an ARAR	These requirements would not be ARARs because they do not apply directly to source-specific emissions; rather, they are limitations on ambient concentrations. However, they would be addressed in controlling emissions that could result from implementation of the remedial action.
Missouri Air Quality Standards; Air Quality Standards, Definitions, Sampling and Reference Methods, and Air Pollution Control Regulations for the State of Missouri (10 CSR 10-6.010), Ambient Air Quality	Particulate matter (PM-10), lead, carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, hydrogen sulfide, sulfuric acid	Air	Concentrations are limited as identified for the National Primary and Secondary Ambient Air Quality Standards (see earlier entry in this table), plus as identified below:	Not an ARAR	These requirements would not be ARARs because they do not apply directly to source-specific emissions; rather, they are limitations on ambient concentrations. However, they would be addressed in controlling emissions that could result from implementation of the remedial action.

Contaminant	Concentration	Condition
Hydrogen sulfide	70 $\mu g/m^3$	0.5-hour average not to be exceeded more than 2 times per year.
	42 $\mu g/m^3$	0.5-hour average not to be exceeded more than 2 times in any 5 consecutive days.
Sulfuric acid	60 $\mu g/m^3$	24-hour average not to be exceeded more than once in any 90 consecutive days.
	30 $\mu g/m^3$	1-hour average not to be exceeded more than once in any 2 consecutive days.

These state regulations address the St. Louis metropolitan area, which includes the geographic area of St. Charles County.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Missouri Air Quality Standards (10 CSR 10-6.060), Permits Required	See table	Air	No owner or operator of an installation listed in these requirements (which included Portland cement plants, municipal incinerators capable of charging more than 250 tons of refuse per day, fossil-fuel boilers of more than 250 million Btu per hour heat input, and chemical process plants) should commence a modification or construction that would result in emissions greater than the de minimis levels identified below:	Potentially relevant and appropriate	This requirement would not be applicable because the Weldon Spring site does not meet the definition for an installation as defined in this regulation. In addition, the requirement for a permit would not be an ARAR because it constitutes an administrative requirement at a CERCLA site; nevertheless, the substantive components of this requirement could be considered relevant and appropriate if the treatment process were considered sufficiently similar to the regulated conditions. For example, if vitrification were selected, emissions might be appropriately controlled to these levels insofar as the vitrification system has the potential to emit pollutants above the specified de minimis levels. Although final emissions from such a facility cannot be determined until after detailed design, preliminary estimates indicate that de minimis levels might be exceeded for nitrogen dioxide and mercury.

Pollutant	Emission Rate (tons/year)
Carbon monoxide	100
Nitrogen dioxide	40
Total suspended particulates	25
PM-10	15
Sulfur dioxide	40
Ozone	40[a]
Lead	0.6
Mercury	0.0004
Asbestos	0.007
Fluorides	3
Sulfuric acid mist	7
Vinyl chloride	1
Hydrogen sulfide	10
Total reduced sulfur	10
Reduced sulfur compounds	10

[a] Measured as volatile organic compounds.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Missouri Acceptable Ambient Levels for Air Quality (Draft)	Specific chemicals (see table)	Air	Ambient air concentrations of the listed parameters should not exceed the following limits (upon promulgation):	To be considered	These draft standards for ambient air quality are currently under consideration by the state of Missouri and have not yet been promulgated, so they are being evaluated as "to be considered" requirements. They would not apply directly to source-specific emissions but instead would be used to support limitations on ambient concentrations; they would be addressed in controlling emissions that could result from implementation of the remedial action.

Parameter	Limit[a] ($\mu g/m^3$)
Aluminum	133.33
Barium	6.67
Chromium	1.33[b]
Copper	2.67
meta-Dinitrobenzene	13.33
2,4-Dinitrotoluene	0.267
2,6-Dinitrotoluene	20
Manganese	0.89
Mercury[c]	0.0089
Nickel[d]	0.27[b]
Nitric oxide	400
Nitrobenzene	13.7[b]
Nitrogen dioxide	100[e]
Thallium	1.33
Trinitrotoluene	0.0889
Uranium[f]	2.67

[a] Averaged over 8 hours, unless otherwise noted.
[b] Averaged over 24 hours.
[c] As elemental mercury.
[d] For soluble salts.
[e] Averaged over 8,760 hours.
[f] As natural uranium.

Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.050), Restriction of Emission of Particulate Matter from Industrial Processes	Particulate matter	Air	Particulate matter from any industrial source should not exceed a concentration of 0.30 grain/ft^3 of exhaust gas; certain activities are exempted (e.g., grinding, crushing, and classifying operations at a rock quarry).	Not an ARAR	These requirements are neither applicable nor relevant and appropriate because no industrial processes are involved in the remedial action and pertinent activities would probably be similar to those for which the waiver is stated. However, they would be addressed in controlling particulate emissions that could be generated during implementation, e.g., from volume reduction activities.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.090), Restriction of Emission of Visible Air Contaminants	Particulate matter	Air	Emissions of particulate matter (<25 lb/h) from any single source, not including uncombined water, should not be darker than the shade of density designated as No. 2 on the Ringelmann Chart, or 40% opacity.	Not an ARAR	These requirements would be neither applicable nor relevant and appropriate because the site does not constitute and is not sufficiently similar to an emission source per the regulatory definition. However, they would be addressed in controlling particulate emissions that could result from implementation of the remedial action.
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.180), Emission of Visible Air Contaminants from Internal Combustion Engines	Particulate matter	Air	Visible air contaminants (other than uncombined water) should not be released from an internal combustion engine for more than 10 seconds at any one time.	Potentially applicable	These requirements would be applicable to particulates released from any internal combustion engines used during the remedial action.
Missouri Air Quality Standards (10 CSR 10-6.170), Restriction of Particulate Matter to the Ambient Air Beyond the Premises of Origin	Particulate matter	Air	No person should permit the handling, transport, or storage of any material without applying reasonable measures as may be required to prevent fugitive particulate matter to go beyond the premises of origin in quantities that (1) the particulate matter remains visible in the ambient air beyond the property line of origin or (2) the particulate matter may be found on surfaces beyond the property line of origin. To prevent particulate matter from going beyond the premises of origin during construction, repair, cleaning, or demolition of a building or its appurtenances; construction or use of a road, driveway, or open area; or operation of a commercial or industrial installation, the following measures may be required: revision of procedures involving construction, repair, cleaning, and demolition of buildings that produce particulate matter emissions, paving or frequent cleaning of roads, application of dust-free surfaces or water, and planting and maintaining a vegetative ground cover.	Potentially applicable	These requirements would be applicable to releases of particulates from the listed activities during implementation of the remedial action.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.030), Maximum Allowable Emissions of Particulate Matter from Fuel-Burning Equipment Used for Indirect Heating	Particulate matter	Air	The maximum allowable particulate emission rate for new sources in an installation of indirect heating sources is 0.40 lb per million Btu of heat input for sources with a heat input of less than 10 million Btu per hour. For sources with a heat input equal to or greater than 10 million Btu per hour and less than or equal to 1,000 million Btu per hour, the maximum allowable particulate emission rate is determined by the equation $E = 0.80(Q)^{-0.301}$, where E is the maximum allowable emission rate in pounds per million Btu of heat input and Q is the installation heat input in millions of Btu per hour. For sources with a heat input rate greater than 1,000 million Btu per hour, the maximum allowable particulate emission rate is 0.10 lb per million Btu of heat input.	Potentially relevant and appropriate	The requirement would not be applicable because fuel-burning equipment would not be used for indirect heating as part of the remedial action. Under the vitrification alternatives, such equipment would be used for direct heating of the waste material; therefore, these requirements could be considered relevant and appropriate for those alternatives on the basis of sufficient similarity.
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart N, National Emission Standard for Inorganic Arsenic Emissions from Glass Manufacturing Plants	Arsenic	Air	Uncontrolled total arsenic emissions from a new glass melting furnace that uses commercial arsenic as a raw material should be limited to 0.4 megatons per year, or control devices should be used to reduce total emissions by at least 85% (except when bypassing is needed, e.g., for maintenance of the control device).	Not an ARAR	These requirements would not be applicable because glass manufacturing is not part of the remedial action; neither would they be relevant and appropriate because, although vitrified waste could be considered sufficiently similar to glass under the vitrification alternatives, commercial arsenic would not be used as the raw material. Nevertheless, these requirements would be addressed in controlling emissions during implementation.
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart M, National Emission Standard for Asbestos	Asbestos	Air	Warning signs should be posted, and discharge of visible emissions should not occur during the collection, processing, packaging, transporting, or deposition of friable asbestos-containing material.	Potentially applicable	This requirement would be applicable to protection of the public during implementation the remedial action.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Asbestos (40 CFR 763), Subpart G, Asbestos Abatement Projects	Asbestos	Air	Programs for worker protection (via clothing and equipment) should be implemented, and the permissible exposure limit for asbestos is 0.2 fiber/cm^3 of air as an 8-hour time-weighted average.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910, 1910.1001), Subpart G, Asbestos, Tremolite, Anthophyllite, and Actinolite	Asbestos	Air	Various asbestos-management activities are required for worker protection, including monitoring, timely response to releases, and the use of high-efficiency-particulate-air (HEPA)-filtered equipment for vacuuming. The permissible occupational exposure limit for asbestos as an 8-hour time-weighted average is 0.2 fiber/cm^3 of air.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.
Occupational Safety and Health Administration Construction Industry Standards (29 CFR 1926)	Asbestos	Air	Worker health and safety standards include a limit for occupational exposure to asbestos of 0.2 fiber/cm^3 of air as an 8-hour time-weighted average, with an action level of 0.1 fiber/cm^3 and a short-term (30-minute) limit of 1 fiber/cm^3 of air (fibers >5 μm).	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart A, General	PCBs	Air	The release of inadvertently generated PCBs at the vent point for emissions should be <10 ppm.	Potentially relevant and appropriate	This requirement would not be applicable because no PCBs would be generated and vented from manufacturing/processing activities as part of the remedial action; however, portions of this requirement could be relevant and appropriate because emissions of the regulated material (PCBs) could potentially occur during implementation and release conditions might be considered sufficiently similar.
Occupational Safety and Health Administration Standards; Occupational Health and Environmental Control (29 CFR 1910, 1910.95), Subpart G, Occupational Noise Exposure	Noise	Air	The permissible occupational exposure level for noise is 90 decibels, A-weighted (dBA) (slow response) for an 8-hour day; with decreasing times of exposure, the levels increase to 115 dBA per 15-minute day.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart B, Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites	Radium-226	Soil	Residual concentrations of radium-226 in soil at a designated uranium processing site should not exceed background by more than 5 pCi/g in the top 15 cm of soil or 15 pCi/g in each 15-cm layer below the top layer, averaged over an area of 100 m^2. (Similar limits are indirectly indicated for radium-228 in Subpart B, which addresses thorium by-product material and therefore could be considered relevant and appropriate; see related discussion relative to radon releases in Table G.3.)	Potentially relevant and appropriate	The Weldon Spring site is not a designated uranium processing site, so these requirements would not be applicable; however, they could be considered relevant and appropriate because the site contains material sufficiently similar to uranium mill tailings and the issue of residual radionuclide concentrations in soil could be well suited to final site conditions.
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Radium and thorium	Soil	Concentrations of radium-226, radium-228, thorium-230, and thorium-232 averaged over an area of 100 m^2 should not exceed 5 pCi/g in the top 15 cm of soil and 15 pCi/g in each 15-cm layer below the top layer. These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and they assume secular equilibrium. If both thorium-230 and radium-226 or both thorium-232 and radium-228 are present and not in secular equilibrium, the appropriate guideline is applied as a limit for the radionuclide with the higher concentration.	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action would comply.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart G, PCB Spill Cleanup Policy	PCBs	Soil	For spills of materials contaminated with >50 ppm PCBs in unrestricted access areas (e.g., residential areas), soil within the spill area should be excavated and backfilled with soil containing <1 ppm PCBs. Contaminated soil may be decontaminated to 10 ppm by weight by excavating a minimum 10 inches and backfilling with soil containing <1 ppm PCBs. For spills at outdoor electrical substations, the soil should be cleaned to 25 ppm by weight (as for other restricted access areas) or to 50 ppm by weight with posting of a visible notice.	Potentially relevant and appropriate	These requirements would not be applicable because any such spills at the site would have preceded the effective date of these regulations. However, they could be considered relevant and appropriate to the remedial action because the waste type (PCBs) and release conditions (spills) may be sufficiently similar to site conditions. The recommended level of 10 ppm by weight was considered in developing a cleanup criterion for PCBs in site soil.

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart G, PCB Spill Cleanup Policy	PCBs	Solid surfaces	Low-concentration spills on hard surfaces that involve less than 1 lb PCBs by weight (less than 270 gal of untested mineral oil) should be cleaned to remove visible traces. Impervious and nonimpervious solid surfaces at outdoor electrical substations contaminated by PCB spills should be cleaned to a PCB concentration of 100 $\mu g/100\ cm^2$ as measured by standard wipe tests. In other restricted access areas, PCB spills on high-contact solid surfaces and on low-contact, indoor impervious and nonimpervious solid surfaces should be decontaminated to 10 $\mu g/100\ cm^2$ (alternatively, low-contact, indoor nonimpervious surfaces could be cleaned to 10 times this level and encapsulated). Low-contact, outdoor impervious and nonimpervious surfaces should be cleaned to 100 $\mu g/100\ m^2$. In areas of unrestricted access, indoor solid surfaces and high-contact outdoor residential/commercial solid surfaces should be cleaned to 100 $\mu g/cm^2$, as should indoor vault areas and low-contact, outdoor impervious and nonimpervious solid surfaces (with an encapsulation option of 10 times this level for the nonimpervious surfaces).	Not an ARAR	These requirements would not be applicable because any such spills at the site would have preceded the effective date of these regulations. Neither would they be relevant and appropriate because it is not the intent of the proposed action to clean surfaces such as floor slabs in areas that would be used in the future. However, these requirements would be considered to address worker safety during implementation.
Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites, OSWER 9355.4-02 (September 7, 1989)	Lead	Soil	A soil cleanup level of 500 to 1,000 ppm for total lead, as indicated by site-specific conditions, has been recommended by the EPA in interim guidance for CERCLA sites. This level is considered protective for direct contact at residential settings. (The EPA has also developed an uptake model, Lead5, that can be used to indicate a site-specific value.)	To be considered	Because this is not a promulgated standard, it is addressed as a "to be considered" requirement. The recommended levels were considered in developing a cleanup criterion for lead in site soil. (The EPA model was also used to develop this level.)

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
Missouri Department of Health, Proposed Rule, 19 CSR 20-9.020, Any-Use Soil Levels for Residential Settings	Specific chemicals (see table)	Soil	The Missouri Department of Health has proposed the following maximum concentrations of chemicals in soil that are considered acceptable to human health in a residential setting (Any-Use Soil Levels [ASL]):	To be considered	Because these are not promulgated standards, they are addressed as "to be considered" requirements. These recommended levels were considered in developing cleanup criteria for site soil.

Contaminant	ASL (ppm)
Antimony	23
Arsenic	11
Barium	3,900
Beryllium	1.2
Cadmium	28
Chromium	5,600[a]
Lead	240
Manganese	5,600
Mercury	17
Molybdenum	56
Nickel	1,100
Selenium	280
Silver	280
Thallium	3.9
Vanadium	170
Zinc	5,600
Anthracene	17,000
Benzo(a)anthracene	0.44
Benzo(b)fluoranthene	0.44
Benzo(k)fluoranthene	0.44
Benzo(a)pyrene	0.44
Chrysene	0.44
Fluorene	2,300
Fluoranthene	2,300
Indeno(1,2,3-cd)pyrene	0.44
Naphthalene	230
Pyrene	1,700
PCBs (total)	0.65

TABLE G.2 (Cont.)

Citation	Contaminant	Medium	Requirement	Preliminary Determination	Remarks
(Cont.)			Contaminant / ASL (ppm): Dinitrobenzene 5.6; 2,4-Dinitrotoluene 7.4; 2,6-Dinitrotoluene 7.4; Nitrobenzene 28; Trinitrotoluene 14. [b] Total concentration in situations where hexavalent chromium is unlikely or documented to be less than 4 ppm. Where hexavalent chromium is likely or documented to exceed 4 ppm, the ASL for total chromium is 280 ppm.		
Federal Water Pollution Control Act, Clean Water Act (33 USC 1251-1376); Criteria and Standards for the National Pollutant Discharge Elimination System (40 CFR 125)	Any	Water	Permitting authority for surface water discharges has been delegated to the state of Missouri for the National Pollutant Discharge Elimination System (NPDES) process. Both procedural and substantive requirements are addressed for the permitting process.	Potentially applicable	These requirements would be applicable to surface water releases from the site, e.g., from construction activities; an NPDES permit is in place with the state of Missouri.

TABLE G.3 Potential Action-Specific Requirements

Citation	Action	Requirement	Preliminary Determination	Remarks
Highway Improvement Act of 1982 (23 USC 127; PL 97-424), Vehicle Weight Limitations — Interstate System	Transportation	Trucks using interstate highways should not exceed weight limits of 20,000 lb for a single axle, 34,000 lb on a tandem axle, and 80,000 lb gross vehicle weight.	Not an ARAR	These requirements are not part of an environmental law and hence are not subject to the ARAR process. However, they could be pertinent to the remedial action for materials shipped on highways (e.g., supplies shipped to the site or wastes transported off-site). In this case, the weight limits would be addressed during implementation.
Hazardous Material Transportation Act, as amended (49 USC 1801-1812); Solid Wastes (40 CFR 263), Standards Applicable to Transportation of Hazardous Waste	Transportation	Generic requirements are established for minimizing the environmental impacts of spills or releases of hazardous materials, as are procedures for transporting hazardous waste.	Not an ARAR	These requirements are not part of an environmental law and hence are not subject to the ARAR process. However, they could be pertinent to the remedial action if hazardous waste was transported off-site. In this case, the pertinent requirements (e.g., for spill response) would be addressed during implementation.
Hazardous Materials Regulations; Shippers — General Requirements for Shipments and Packaging (49 CFR 173), Subpart I, Radioactive Materials	Transportation	Low-specific-activity radioactivity materials should be packaged in strong, tight containers to prevent leakage of radioactivity under conditions normally incident to transportation, and the vehicles should be placarded. In exclusive-use vehicles, external radiation levels on packages should be <200 mrem/h or <1,000 mrem/h if secured in a closed transport vehicle with no intermediate loading or unloading; external radiation levels on the outer surface of the vehicle are limited to <200 mrem/h at any point and <10 mrem/h at 2 m from the surface of the vehicle; and levels in any normally occupied space are limited to <2 mrem/h.	Not an ARAR	These requirements are not part of an environmental law and hence are not subject to the ARAR process. However, they could be pertinent to the remedial action if the waste was transported off-site because the average concentration of radionuclides in certain waste could meet the criteria for classification as low-specific-activity radioactive material. In this case, such requirements would be addressed during implementation.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Missouri Rules Applicable to Transporters of Hazardous Waste (10 CSR 25-6.263), Standards for Transporters of Hazardous Waste	Transportation	Equipment used to transport hazardous waste should meet state and federal standards and should be compatible with the waste and adequate to protect human health and prevent environmental damage. Motor vehicle operators should be licensed by the Missouri Department of Natural Resources.	Not an ARAR	These requirements are not part of an environmental law and hence are not subject to the ARAR process. However, they could be pertinent to the remedial action if hazardous waste was transported off-site. In this case, the pertinent requirements (e.g., for equipment and licensing) would be addressed during implementation.
Missouri Air Pollution Control Regulations; Air Quality Standards and Air Pollution Control Regulations for the St. Louis Metropolitan Area (10 CSR 10-5.310), Liquefied Cutback Asphalt Restricted	Roadway construction	The use of liquefied cutback (asphalt cement that is liquefied by blending with petroleum solvents as diluents) on roadways, driveways, or parking lots is not permitted during the months of May through September; this restriction applies to the asphalt used as a plant mix or road mix and does not apply to its use as pothole filler, for emergency repair, or as a primer coat or seal on absorbent surfaces.	Potentially applicable	These requirements would be applicable to construction of haul roads as part of the remedial action.
Noise Control Act, as Amended; Noise Pollution and Abatement Act	Construction and treatment activities	The public should be protected from noises that jeopardize human health or welfare.	Potentially applicable	These requirements would be applicable to the remedial action.
Occupational Safety and Health Administration Standards for Hazardous Waste Operations and Emergency Response (29 CFR 1910)	Decontamination and waste handling	General worker protection requirements are established, as are requirements for worker training and the development of an emergency response plan and a safety and health program for employees. In addition, procedures are established for hazardous waste operations — including decontamination and drum/container handling (e.g., for radioactive waste, asbestos, and PCBs).	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
U.S. Nuclear Regulatory Commission Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material	Decontamination	Structural debris associated with licensed by-product, source, or special nuclear material that is released for reuse without radiological restrictions should be decontaminated to specified levels. The allowable total residual surface contamination levels for transuranics, iodine-125, iodine-129, radium-226, actinium-227, radium-228, thorium-228, thorium-230, and protactinium-231 are as follows: average, 100 dpm/100 cm^2; maximum, 300 dpm/100 cm^2; and removable, 20 dpm/100 cm^2.	To be considered	These are "to be considered" requirements because they are guidelines rather than promulgated standards; however, the Weldon Spring site is not a nuclear facility licensed by the U.S. Nuclear Regulatory Commission (NRC), and most of the requirements listed in the guidelines have been incorporated into DOE Order 5400.5, with which the remedial action would comply (see later entry in this table). Because this Order does not include the limits shown here, they might be considered pertinent to the release of structural material for reuse without radiological restrictions.
Termination of Operating Licenses for Nuclear Reactors (U.S. Nuclear Regulatory Commission Regulatory Guide 1.86)	Decontamination	Structural debris associated with licensed reactors that is released for reuse without radiological restrictions should be decontaminated to specified levels. (The allowable surface contamination levels included in this regulatory guide are identical to those discussed in the previous entry in this table.)	To be considered	These are "to be considered" requirements because they are guidelines rather than promulgated standards; however, the Weldon Spring site is not a nuclear facility licensed by the NRC, and most of the requirements listed in the guidelines have been incorporated into DOE Order 5400.5, with which the remedial action would comply (see next entry). These requirements might be considered pertinent to the release of structural material for reuse without radiological restrictions.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Decontamination	Structural debris that is released from DOE facilities for reuse without radiological restrictions should be decontaminated to the following levels:	To be considered	Although not promulgated standards, these constitute requirements for protection of the public with which the remedial action would comply.

	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[a]		
Radionuclides[b]	Average[c,d]	Maximum[e]	Removable[d,f]
Transuranics, iodine-125, iodine-129, radium-226, actinium-227, radium-228, thorium-228, thorium-230, protactinium-231	Reserved	Reserved	Reserved
Thorium-natural, strontium-90, iodine-126, iodine-131, iodine-133, radium-223, radium-224, uranium-232, thorium-232	1,000	3,000	200

TABLE G.3 (Cont.)

Citation	Action	Requirement			Preliminary Determination	Remarks
(Cont.)		Allowable Total Residual Surface Contamination (dpm/100 cm^2)[a]				
		Radionuclides[b]	Average[c,d]	Maximum[e]	Removable[d,f]	
		Uranium-natural, uranium-235, uranium-238, and associated decay products, alpha emitters	5,000	15,000	1,000	
		Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except strontium-90 and others noted above[g]	5,000	15,000	1,000	

[a] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

Footnotes continued on next page.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
(Cont.)		[b] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently. [c] Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of smaller surface area, the average should be derived for each such object. [d] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm. [e] The maximum contamination level applies to an area of not more than 100 cm^2. [f] The amount of removable material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper (applying moderate pressure) and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination. [g] This category of radionuclides includes mixed fission products, including strontium-90, that have been separated from other fission products or mixtures where the strontium-90 has been enriched.		

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Occupational Safety and Health Administration Standards for Hazardous Waste Operations and Emergency Response (29 CFR 1910)	Waste management	General worker protection requirements are established, as are requirements for worker training and the development of an emergency response plan and a safety and health program for employees. In addition, procedures are established for hazardous waste operations — including decontamination and drum/container handling (e.g., for radioactive waste, asbestos, and PCBs).	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which all CERCLA response actions should comply; hence, they are not subject to the ARAR process. They are indicated in this table to identify requirements for worker protection with which the remedial action would comply.
Radioactive Waste Management (DOE Order 5820.2A)	Radioactive waste management	External exposure to radioactive waste (including releases) should not result in an effective dose equivalent of >25 mrem/yr to any member of the public, and releases to the atmosphere should meet the requirements of 40 CFR 61 (see related discussion for contaminant-specific requirements). An environmental monitoring program should be implemented to address compliance with performance standards.	To be considered	Although not promulgated standards, these constitute requirements for controlling exposures and releases and for environmental monitoring with which the remedial action would comply. The current monitoring program for the site would be expanded during the action period of site cleanup.
Hazardous and Radioactive Mixed Waste Program (DOE Order 5400.3)	Mixed waste management	The hazardous waste component of hazardous and radioactive mixed wastes should be managed according to the requirements of the Solid Waste Disposal Act, as amended (commonly referred to as the Resource Conservation and Recovery Act [RCRA]), and the radioactive component of radioactive mixed waste should be managed according to the requirements of DOE Order 5820.2A (see related discussion in this table). Waste minimization measures should also be implemented.	To be considered	Although not promulgated standards, these constitute requirements with which the remedial action would comply if site waste met the prerequisites for definition as hazardous waste; in this case, the pertinent requirements of RCRA would be addressed.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Interim radioactive waste storage and management	The control and stabilization features of a storage facility for waste containing uranium, thorium, and their decay products should be designed to ensure an effective life of 50 years, with a minimum life of at least 25 years, to the extent reasonably achievable; site access controls should be designed to ensure an effective life of at least 25 years, to the extent reasonable; and periodic monitoring, shielding, access restrictions, and safety measures should be implemented to control the migration of radioactive material, as appropriate.	To be considered	Although not promulgated standards, these constitute requirements for storage and management of waste with which the remedial action would comply.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.070), Storage of Radioactive Materials	Radioactive waste storage	Radioactive materials should be stored in a manner that will not result in the exposure of any person, during routine access to a controlled area, in excess of the limits identified in 19 CSR 20-10.040 (see related discussion for contaminant-specific requirements); a facility used to store materials that may emit radioactive gases or airborne particulate matter should be vented to ensure that the concentration of such substances in air does not constitute a radiation hazard; and provisions should be made to minimize the hazard to emergency workers in the event of a fire, earthquake, flood, or windstorm.	Potentially applicable	These requirements would be applicable to the temporary storage of certain material that would be generated during the remedial action, pending the availability of a disposal facility.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.080), Control of Radioactive Contamination	Radioactive waste management	All work should be carried out under conditions that minimize the potential spread of radioactive material that could result in the exposure of any person above any limit specified in 19 CSR 20-10.040 (see related discussion for contaminant-specific requirements). Clothing and other personal contamination should be monitored and removed according to procedures established by a qualified expert; any material contaminated to the degree that a person could be exposed to radiation above any limit specified in 19 CSR 20-10.040 should be retained on-site until it can be decontaminated or disposed of according to procedures established by a qualified expert.	Not an ARAR	These requirements are part of an employee protection law (rather than an environmental law) with which CERCLA response actions should comply; hence, they are not subject to the ARAR process. However, they constitute requirements for worker protection with which the proposed action would comply.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart A, Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites	Radioactive waste disposal	Control of residual radioactive materials at designated uranium processing or depository sites should be designed to be effective for at least 200 years and up to 1,000 years, to the extent reasonably achievable. In addition, the control should be designed such that releases of radon-222 from the residual radioactive material would not exceed an average rate of 20 pCi/m^2-s or increase the annual average concentration in air outside the disposal site by more than 0.5 pCi/L. Because this standard applies to design, monitoring after disposal is not required to demonstrate compliance.	Potentially relevant and appropriate	The Weldon Spring site is not a designated uranium processing or depository site, so these requirements would not be applicable. However, they would be considered relevant and appropriate to the design of a disposal facility because the site contains material sufficiently similar to uranium mill tailings and the potential release issue could be considered well suited to final site conditions.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192), Subpart D, Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the U.S. Atomic Energy Act of 1954, as amended; Subpart E, Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the U.S. Atomic Energy Act of 1954, as amended.	Radioactive waste disposal	Disposal areas for uranium and thorium by-product materials should be designed to be effective for at least 200 years and up to 1,000 years, to the extent reasonably achievable. In addition, the control should be designed so that releases of radon-222 and radon-220 from these materials (i.e., excluding the cover) would not exceed an average rate of 20 pCi/m^2-s. The standard applies to design, so monitoring for radon after installation of an appropriately designed cover is not required. (This requirement does not apply to any portion of the site that contains residual surface and subsurface concentrations of radium-226 and radium-228 at or below those identified in Subparts B and E, respectively, which are listed with "soil" in Table G.2.)	Potentially applicable	These requirements would be applicable to the remedial action because uranium and thorium ore concentrates were processed at the site, thereby generating uranium and thorium by-product materials.
Atomic Energy Act, as amended (42 USC 2112)	Radioactive waste disposal	The DOE can distribute by-product material only to individuals or organizations who are licensed by the NRC to receive such material.	Potentially applicable	These requirements would be applicable to the disposal of radioactively contaminated (by-product) material from the Weldon Spring site at a commercial facility (e.g., the Envirocare site near Clive, Utah).

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Radioactive Waste Management (DOE Order 5820.2A)	Radioactive waste disposal	Large quantities of 11e(2) by-product material waste should be managed according to the requirements of 40 CFR 192 and disposed of at specially designated DOE sites. These disposal sites should be identified and developed as needed to support DOE remedial action and should normally be located in the state in which the wastes are generated. Control and stabilization features for long-term management facilities should provide, to the extent reasonably achievable, an effective life of 1,000 years with a minimum life of at least 200 years. Emanation of radon-222 should be limited to an annual average release rate of 20 pCi/m^2-s, and the annual average concentration of radon-222 outside the site boundary should not be increased by more than 0.5 pCi/L. Potentially biodegradable wastes should be conditioned to limit biogenic gas generation; groundwater should be protected; and access should be controlled, with controls designed to be effective to the extent reasonable for at least 200 years.	To be considered	Although not promulgated standards, these constitute requirements with which the remedial action would comply.
Missouri Radiation Regulations; Protection Against Ionizing Radiation (19 CSR 20-10.090), Disposal of Radioactive Wastes	Radioactive waste disposal	Radioactive waste material should not be disposed of by dumping or burial in soil, except at sites approved by and registered with the Missouri Department of Health; a permit should be obtained for holding and preparation of such material prior to disposal; and no releases to air or water should cause exposure of any person above the limits specified in 19 CSR 20-10.041 (see related discussion for contaminant-specific requirements).	Potentially applicable	Certain of these requirements would be applicable to the action. (No permit would be required for on-site disposal because this would constitute an on-site CERCLA action for which such administrative requirements are not ARARs; however, the substantive components of such a permit would be addressed.)

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart A, General	PCB management	Applicability of requirements and definitions are identified for material contaminated with PCBs.	Potentially applicable	These requirements would be applicable to management of material potentially contaminated with PCBs. Characterization of PCB-contaminated material has previously been conducted at the site (e.g., for both structures and soil) and would continue as part of the remedial action.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart C, Marking of PCBs and PCB Items	PCB removal and storage	Requirements for marking PCB containers are identified.	Potentially applicable	This requirement would be applicable to the removal and storage of material contaminated with PCBs.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469 et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart D, Storage and Disposal	PCB storage	Material contaminated with PCBs at concentrations greater than 50 ppm should be stored for disposal (for no longer than 1 year) in a facility marked for storage and not located in a 100-year floodplain. The facility should have adequate roof and walls to prevent rain water from reaching the stored material and an impervious floor; the impervious floor should have continuous curbing at a minimum of 6 in. high (with no openings within the curbed area) that allows for a containment volume equal to two times the internal volume of the largest PCB article or container stored therein or 25% of the total internal volume of all PCB articles and containers, whichever is greater. The material should be checked monthly for leaks.	Potentially applicable	This requirement would be applicable to the storage of material contaminated with PCBs. For the action alternatives, a waiver from the time limitation would be pertinent during the remedial action for the radioactively contaminated PCBs currently in storage at the site on the basis of technical impracticability — i.e., a facility is not yet available in which to dispose of this waste. In addition, this storage would be an intermediate measure and the requirement would be attained upon completion of the remedial action.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469, et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761), Subpart D, Storage and Disposal	PCB incineration	Liquid PCBs should be incinerated in an EPA-approved facility either for 2 seconds at 1,200°C with 3% excess oxygen in the stack gas or for 1.5 seconds at 1,600°C with 2% excess oxygen in the stack gas. The combustion efficiency should be 99.9%, the rate and quantity of PCBs fed to the facility should be measured and recorded, the stack gas should be monitored, and water scrubbers should be used to control hydrochloric acid (HCl). Nonliquid PCBs should be incinerated in an EPA-approved facility with the same combustion efficiency and monitoring requirements, and mass air emissions from the facility should be no greater than 0.001 g/kg of the PCB introduced.	Potentially applicable	These requirements would be applicable if site waste was contaminated with PCBs above the level indicated for treatment or disposal (see previous entries) and the PCB-contaminated material was to be incinerated.
Toxic Substances Control Act, as amended (15 USC 2607-2629; PL 94-469, et seq.); Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761); Subpart D, Storage and Disposal	PCB disposal	Wastes that are not chemically compatible with PCBs should be segregated from the PCBs throughout the waste handling and disposal process. Bulk liquids not exceeding 500 ppm PCBs may be disposed of, provided such waste is pretreated and/or stabilized (e.g., chemically fixed, evaporated, or mixed with dry absorbent) to reduce its liquid content or increase its solid content so that a nonflowing consistency is achieved to eliminate the presence of free liquids prior to final disposal in a landfill. Material contaminated with PCBs at concentrations from 50 to 500 ppm (including dredged material) should be incinerated or disposed of in an approved chemical waste landfill. Containers for articles with PCBs at <500 ppm can be disposed of in a chemical waste landfill if it is not an ignitable waste. Any PCB articles with ≥500 ppm PCBs and nonliquid material with ≥50 ppm PCBs (e.g., contaminated soil, rags, or other debris) should be disposed of by incinerating (or using an alternative treatment) or landfilling. The chemical waste landfill should be located in an area with an in-place soil thickness of 4 ft or a compacted thickness of 3 ft and a soil permeability of at least 10^{-7} cm/s, >30% passing through a No. 200 sieve, a liquid limit >30, and a plasticity index >15;	Potentially applicable	These requirements would be applicable to the disposal of residual site material contaminated with PCBs. Limited site soil and some process chemicals in storage at Building 434 are contaminated with PCBs at this level and two outdoor tanks (with secondary containment) contain tributyl phosphate contaminated with PCBs at about 150 ppm. A number of nonradioactively contaminated PCB liquids and containers were previously removed from the site for treatment and disposal at a licensed facility as part of an interim action.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
(Cont.)		a synthetic liner (with a minimum thickness of 30 mil) can be used to achieve an equivalent permeability. The landfill should also contain a leachate collection system, which can be a simple gravity-flow drainfield, a compound system (where a double liner is present), or a suction lysimeter network. The bottom of the landfill should be ≥50 ft above the historical high groundwater table, and the site should not be hydrologically connected to standing or flowing water. Structures should be in place to divert runoff from a 24-hour, 25-year storm. If located below the 100-year floodwater elevation, 2-ft surface water diversion dikes should surround the landfill. The landfill should be located in an area of low to moderate relief to minimize erosion, landslides, and slumping. Surface water and the leachate collection system should be monitored (monthly during operations, then twice a year for surface water), as should groundwater.		
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart M, National Emission Standard for Asbestos	Asbestos management	Asbestos-containing material from manufacturing, demolition, renovation, spraying, and fabricating operations should be wet and sealed in labeled, leak-tight containers to prepare for its disposal.	Potentially applicable	These requirements would be applicable to the management of asbestos during the remedial action.
National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Subpart M, National Emission Standards for Asbestos, 61.154, Standard for Active Waste Disposal Sites	Asbestos disposal	There should be no visible emissions to the outside air from any active waste disposal site where asbestos-containing waste material has been deposited, or asbestos-containing material should be covered with at least 15 cm (6 in.) of compacted non-asbestos containing material (or be covered with a resinous dust suppression agent that effectively binds dust and controls wind erosion) at least once every 24 hours or at the end of each operating day.	Potentially applicable	This requirement would be applicable to the disposal of asbestos-containing material.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Criteria for Classification of Solid Waste Disposal Facilities and Practices (40 CFR 257)	Solid waste disposal	This rule identifies general environmental performance standards for solid waste disposal facilities and practices addressing floodplains, endangered species, surface water, groundwater, air, and safety.	Potentially relevant and appropriate	These requirements would not be applicable because they specifically exclude the disposal of source, special nuclear, and by-product material (which is present at the site) as defined by the Atomic Energy Act of 1954, as amended. However, because they identify generic requirements for disposal of solid wastes, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type and actions could be considered sufficiently similar.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Criteria for Municipal Solid Waste Landfills (40 CFR 258), Subpart B, Location Restrictions	Solid waste disposal	General requirements are established for locating solid waste disposal facilities. Location requirements include (1) facilities located in a 100-year floodplain should be constructed, operated, and maintained such that they do not restrict the flow or storage capacity of the 100-year flood or result in washout of any waste by a 100-year flood; (2) facilities should not be located in wetlands and shall not cause or contribute to significant degradation of wetlands; (3) facilities should not be located within 60 m (200 ft) of a fault in which displacement has occurred in Holocene time (i.e., since the end of the Pleistocene); (4) facilities should not be located in a seismic impact zone (an area with a 10% or greater probability that the maximum horizontal gravitational acceleration [g] in lithified earth material will exceed 0.1 g in 250 years) unless all containment structures, liners, leachate collection systems, and surface water control systems are designed to resist maximum horizontal acceleration at the site; (5) for facilities located in unstable areas (areas with poor foundation materials, areas susceptible to mass movement, and karst terrain), it should be demonstrated that engineering measures in such a facility's design ensure the integrity of the structural components of that facility.	Potentially relevant and appropriate	These requirements would not be applicable because they apply only to owners/operators of municipal solid waste landfill units (units that receive household waste or other RCRA Subtitle D waste, e.g., commercial solid waste, nonhazardous sludge, and industrial solid waste) and because they do not apply to source, special nuclear, or by-product material. Nevertheless, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar. The conceptual location for an on-site disposal cell is not within the established fault distance or in a 100-year floodplain; the other factors would be incorporated into the remedial design phase.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Criteria for Municipal Solid Waste Landfills (40 CFR 258), Subpart C, Operating Criteria	Solid waste disposal	Various operating criteria for owners and operators of solid waste disposal facilities are established. Operating requirements include (1) procedures for precluding the placement of hazardous wastes; (2) placement of at least 6 in. of cover material over the waste at the end of each operating day; (3) criteria for disease vector control and explosive gas control; (4) criteria for meeting air quality requirements pursuant to the Clean Air Act, as amended; (5) runon and runoff control systems for preventing flow onto the active portion of the landfill and collection of flow from the landfill for the peak discharge of a 25-year storm and a 24-hour, 25-year storm, respectively; (6) restriction of discharges to surface waters in violation of the Clean Water Act, as amended; (7) prohibition of bulk or noncontainerized free liquids; and (8) recordkeeping requirements.	Potentially relevant and appropriate	These requirements would not be applicable because they apply only to owners/operators of municipal solid waste landfill units (units that receive household waste or other RCRA Subtitle D waste, e.g., commercial solid waste, nonhazardous sludge, and industrial solid waste) and because they do not apply to source, special nuclear, or by-product material. Nevertheless, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar. (The recordkeeping requirements would not be ARARs because they constitute administrative requirements at a CERCLA site; nevertheless, the substantive components would be addressed as part of the standard record-keeping practices for the project.)

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Criteria for Municipal Solid Waste Landfills (40 CFR 258), Subpart D, Design Criteria	Solid waste disposal	Disposal facilities should be designed and constructed such that the maximum contaminant levels (MCLs) identified below are not exceeded in the uppermost aquifer at the relevant point of compliance as specified by the director of an approved state, or the facility should include a composite liner and leachate collection system designed and constructed to maintain less than a 30-cm depth of leachate over the liner. The composite liner should consist of an upper flexible membrane liner installed in direct and continuous contact with at least 2 ft of compacted soil with a hydraulic conductivity of no more than 10^{-7} cm/s.	Potentially relevant and appropriate	These requirements would not be applicable because they apply only to owners/operators of municipal solid waste landfill units (units that receive household waste or other RCRA Subtitle D waste, e.g., commercial solid waste, nonhazardous sludge, and industrial solid waste) and because they do not apply to source, special nuclear, or by-product material. Nevertheless, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar.

Chemical	MCL (mg/L)
Arsenic	0.05
Barium	1.0
Benzene	0.005
Cadmium	0.01
Carbon tetrachloride	0.005
Chromium (hexavalent)	0.05
2,4-Dichlorophenoxy acetic acid	0.1
1,4-Dichlorobenzene	0.075
1,2-Dichloroethane	0.005
1,1-Dichloroethylene	0.007
Endrin	0.0002
Fluoride	4
Lindane	0.004
Lead	0.05
Mercury	0.002
Methoxychlor	0.1
Nitrate	10

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks

(Cont.)

Chemical	MCL (mg/L)
Selenium	0.01
Silver	0.05
Toxaphene	0.005
1,1,1-Trichloromethane	0.2
Trichloroethylene	0.005
2,4,5-Trichlorophenoxy acetic acid	0.01
Vinyl chloride	0.002

The relevant point of compliance should be no more than 150 ft from the waste management unit boundary and on land owned by the owner of the facility. The point of compliance is determined by considering the local hydrogeology; volume, physical, and chemical characteristics of potential leachate; quantity, quality, and direction of groundwater flow; proximity and withdrawal rate of groundwater users; and availability of an alternate water supply.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Criteria for Municipal Solid Waste Landfills (40 CFR 258), Subpart E, Groundwater Monitoring and Corrective Action	Solid waste disposal	Requirements are specified for groundwater monitoring, groundwater sampling and analysis, detection monitoring, and corrective action. The groundwater monitoring system must comprise a sufficient number of wells at appropriate locations and depths to yield samples from the uppermost aquifer at the site to determine (1) background groundwater quality and (2) downgradient groundwater quality at the point of compliance.	Potentially relevant and appropriate	These requirements would not be applicable because they apply only to owners/operators of municipal solid waste landfill units (units that receive household waste or other RCRA Subtitle D waste, e.g., commercial solid waste, nonhazardous sludge, and industrial solid waste) and because they do not apply to source, special nuclear, or by-product material. Nevertheless, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Criteria for Municipal Solid Waste Landfills (40 CFR 258), Subpart F, Closure and Post-Closure Care	Solid waste disposal	Criteria for closure of a landfill unit and post-closure care requirements are specified. Cover system design requirements at closure include (1) an infiltration layer constructed of a minimum of 18 in. of earthen material with a permeability less than or equal to the permeability of the bottom liner system or no greater than 1×10^{-5} cm/s, whichever is less, and (2) an erosion protection layer of earthen material capable of supporting native plant growth; or equivalents approved by the director of an approved state program. Post-closure care requires maintenance of the integrity of the final cover system, the leachate collection system, groundwater monitoring, and gas monitoring for a period of 30 years or as necessary to protect human health and the environment. Management of the leachate may be terminated if the owner/operator demonstrates that leachate no longer poses a threat to human health and the environment.	Potentially relevant and appropriate	These requirements would not be applicable because they apply only to owners/operators of municipal solid waste landfill units (units that receive household waste or other RCRA Subtitle D waste, e.g., commercial solid waste, nonhazardous sludge, and industrial solid waste) and because they do not apply to source, special nuclear, or by-product material. Nevertheless, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Criteria for Municipal Solid Waste Landfills (40 CFR 258), Subpart G, Financial Assurance Criteria	Solid waste disposal	General financial requirements are established for owners and operators of municipal solid waste landfill units.	Potentially applicable/ not an ARAR	These requirements would be applicable for the owner of a commercial facility if site waste met the definition of a solid waste and the waste was disposed of in such a facility. If the waste were disposed of in an on-site facility, these requirements would be neither applicable nor relevant and appropriate because the federal government is specifically exempt from them.
Missouri Solid Waste Rules (10 CSR 80), Chapter 3, Sanitary Landfills, Design and Operation, 3.010(1), General Provisions	Solid waste disposal	Requirements and methods are identified for ensuring that the design, construction, and operation of sanitary landfills will protect public health, prevent nuisances, and meet applicable environmental standards.	Not an ARAR	These requirements would not be applicable because they do not apply to source, special nuclear, or by-product material. They would also not be relevant and appropriate because they address disposal requirements for municipal waste, which contains considerable organic matter such that site waste is not sufficiently similar.
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(1), General Provisions	Solid waste disposal	Requirements and methods are identified for ensuring that the design, construction, and operation of demolition landfills will protect public health, prevent nuisances, and meet applicable environmental standards. If techniques other than those listed are used, the owner/operator should demonstrate in advance that the techniques will satisfy the requirements.	Potentially relevant and appropriate	These requirements would not be applicable because they do not apply to source, special nuclear, or by-product material. However, because they address demolition and construction debris, brush and wood wastes, soil, rock, concrete, and related inert materials that are relatively insoluble in water, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills 4.010(2), Solid Wastes Accepted	Solid waste disposal	Only the following wastes should be accepted for disposal in a permitted demolition landfill: demolition wastes, construction wastes, brush, wood wastes, tires, inert plastics, soil, rock, concrete, sand, gravel, asphaltic concrete, cinderblocks, and bricks. Other inert solids relatively insoluble in water should only be accepted in accordance with Subsection (3) of this rule (see following entry). Demolition wastes should not contain more than a minor amount of metals. Permits should specify the types of solid wastes to be received and the procedures to be employed for disposal of waste requiring special handling.	Potentially applicable/ not an ARAR	These requirements would be applicable if this solid waste were disposed of off-site in Missouri. However, they would be neither applicable nor relevant and appropriate to on-site actions because they constitute administrative requirements at a CERCLA site.
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(3), Solid Wastes Excluded and Special Waste Approvals	Solid waste disposal	Administrative requirements are identified for obtaining approval to dispose of wastes not specifically listed in Subsection (2) of this rule (see previous entry).	Potentially applicable/ not an ARAR	These requirements would be applicable if this solid waste were disposed of off-site in Missouri. However, they would be neither applicable nor relevant and appropriate to on-site actions because they constitute administrative requirements at a CERCLA site.
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(4), Site Selection	Solid waste disposal	Site selection and utilization should comply with local zoning requirements. Study and evaluation of geologic and hydrologic conditions and of the environmental effect upon projected use of the completed landfill should be performed. Proposed topographies at the landfill and area land use within 0.25 mi of the landfill should be identified, as should the projected use of the completed landfill. The hydrology of the site should be evaluated to allow design of the landfill such that impacts to surface water and groundwater resources are minimized. On-site soils should be evaluated with respect to their suitability in terms of texture, plasticity, hydraulic conductivity, and depth, and the engineering properties of on-site bedrock should be evaluated.	Potentially relevant and appropriate	These requirements would not be applicable because they do not apply to source, special nuclear, or by-product material. However, because they address demolition and construction debris, brush and wood wastes, soil, rock, concrete, and related inert materials that are relatively insoluble in water, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(5), Design	Solid waste disposal	A minimum 50-ft buffer zone between the landfill operations and the property boundary should be maintained. Plans for design, construction, and operation should be prepared or approved by a professional engineer.	Potentially relevant and appropriate	These requirements would not be applicable because they do not apply to source, special nuclear, or by-product material. However, because they address demolition and construction debris, brush and wood wastes, soil, rock, concrete, and related inert materials that are relatively insoluble in water, the buffer zone requirement could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar. (The preparation and approval of plans would not be ARARs for an on-site action because they constitute administrative requirements at a CERCLA site; nevertheless, the substantive components would be addressed as part of standard project planning.)
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(6), Survey Control	Solid waste disposal	Benchmarks, horizontal controls, and boundary markers should be established by a land surveyor to check and mark the location and elevations of the landfill; these features should be maintained.	Potentially relevant and appropriate	These requirements would not be applicable because they do not apply to source, special nuclear, or by-product material. However, because they address demolition and construction debris, brush and wood wastes, soil, rock, concrete, and related inert materials that are relatively insoluble in water, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(7), Water Quality	Solid waste disposal	The location, design, construction, and operation of the demolition landfill should minimize environmental hazards and conform to applicable ground and surface water quality standards and requirements. On-site drainage structures and channels should be designed to prevent flow onto the active portion of the landfill during peak discharge from at least a 25-year storm and to collect and control at least the water volume resulting from a 24-hour, 25-year storm. If the landfill is located in a floodplain, it should be protected against the 100-year flood by dikes or other measures to prevent flood wastes from contacting the solid waste, but these structures should not restrict the flood flow from the 100-year flood. The landfill cells should be graded and operated to promote rapid runoff without excessive erosion. A leachate collection system to collect and/or remove leachate should be constructed of materials that are chemically resistant to the waste and expected leachate and are of sufficient strength and thickness to prevent collapse, and it should be designed and operated to prevent clogging; the leachate should flow by gravity into collection sumps. The leachate collection system should be maintained for a 20-year post-closure period or as necessary to prevent discharge of leachate and/or contamination to surface water or groundwater. Leachate discharge should be in accordance with the Clean Water Act. The landfill should have bottom and side liners designed to minimize migration of leachate and should be constructed of either (1) soil compacted to a minimum thickness of 2 ft to 95% standard Proctor density at moisture content between 2% below and 4% above minimum with a coefficient of permeability $\leq 10^{-6}$ cm/s or (2) man-made liner material with chemical properties and strength/thickness sufficient to prevent failure as a result of pressure gradients, physical contact with the waste or leachate, climatic conditions, and the stress of installation and daily operations. The owner/operator may be exempt from these design requirements if the design utilized will minimize (to the satisfaction of the Missouri Department of Natural Resources) migration of waste constituents into groundwater or surface water as effectively as the minimum standards set forth above.	Potentially relevant and appropriate	These requirements would not be applicable because they do not apply to source, special nuclear, or by-product material. However, because they address demolition and construction debris, brush and wood wastes, soil, rock, concrete, and related inert materials that are relatively insoluble in water, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(8), Groundwater Monitoring	Solid waste disposal	The owner/operator should implement a groundwater monitoring program capable of determining the demolition landfill's impact on the quality of the groundwater underlying the landfill. This system should consist of at least one background and three downgradient wells cased to maintain the integrity of the monitoring well borehole, and the wells should be sampled quarterly and annually for specified indicator parameters. A remedial action plan should be developed if a statistically significant difference in groundwater quality is detected.	Potentially relevant and appropriate	These requirements would not be applicable because they do not apply to source, special nuclear, or by-product material. However, because they address demolition and construction debris, brush and wood wastes, soil, rock, concrete, and related inert materials that are relatively insoluble in water, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar. (Although preparation of the plan would not be an ARAR for an on-site action because it would constitute an administrative requirement at a CERCLA site, the substantive components would be addressed as part of good management practice for the project.)
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(9), Air Quality	Solid waste disposal	The design, construction, and operation of the landfill should minimize environmental hazards and conform to applicable ambient air quality and source control regulations.	Potentially relevant and appropriate	These requirements would not be applicable because they do not apply to source, special nuclear, or by-product material. However, because they address demolition and construction debris, brush and wood wastes, soil, rock, concrete, and related inert materials that are relatively insoluble in water, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Missouri Solid Waste Rules (10 CSR 80), Chapter 4, Demolition Landfills, 4.010(13), Cover	Solid waste disposal	The landfill should be covered to minimize fire hazard, infiltration of precipitation, odors and blowing litter; control gas venting and vectors; discourage scavenging; and provide a pleasing appearance. Surface grades and side slopes should not exceed a ratio of 3:1 (horizontal to vertical). The final cover should be at least 2 ft of compacted cap overlain by 1 ft of soil capable of supporting vegetative growth.	Potentially relevant and appropriate	These requirements would not be applicable because they do not apply to source, special nuclear, or by-product material. However, because they address demolition and construction debris, brush and wood wastes, soil, rock, concrete, and related inert materials that are relatively insoluble in water, certain requirements could be considered relevant and appropriate to the disposal of some nonhazardous waste from the site because the waste type could be considered sufficiently similar.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Identification and Listing of Hazardous Waste (40 CFR 261), Subpart C, Characteristics of Hazardous Waste; Subpart D, List of Hazardous Wastes	Hazardous waste characterization and management	A waste should be evaluated to determine if it is a hazardous waste, i.e., either a waste listed in this requirement or a characteristic waste. Listed wastes are defined in terms of the source, prior use, or process type that resulted in the waste material. The three groups of listed waste are (1) waste from nonspecific sources (F waste codes), (2) waste from specific sources (K waste codes), and (3) discarded commercial chemical products, off-specification species, container residues, and spill residues thereof (P and U waste codes). A characteristic waste is determined by its (1) ignitability (defined by flash point, oxidizer, and other); (2) corrosivity (defined by pH ≤2 or ≥12.5, rate of steel corrosion, and other); (3) reactivity (defined by instability, violent reaction with water, explosivity, cyanide- or sulfide-bearing nature with vapor generation potential, and other); or (4) leachability (defined by an established toxicity characteristic leachate procedure [TCLP]). The following table lists the concentrations of specific contaminants in leachate from a representative waste sample in which the toxicity characteristic is exhibited:	Potentially applicable	This requirement would be applicable to the characterization and management of material generated by the action. Contaminated material at the site has been and will continue to be evaluated to determine whether the prerequisites for definition as hazardous waste are met from either the listed definition or the characteristic definition. The concentrations of certain chemicals, such as 2,4-dinitrotoluene in the leachate of some soil fractions (e.g., from the quarry), are expected to exceed the limits identified for characteristic waste, so some site material would be defined as such. To determine if site waste is a listed hazardous waste, specific information is used regarding the waste, such as the source, prior use, and process type determined within the scope of the CERCLA investigation. Records or other specific information must be available to identify the source of the waste in order to determine that the waste is a listed hazardous waste. No listed waste has been identified at the site; the containerized chemicals stored in Building 434 continue to be evaluated.

Contaminant	Concentration (mg/L)
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol	200.0
m-Cresol	200.0
p-Cresol	200.0
Cresol	200.0

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks

(Cont.)

Contaminant	Concentration (mg/L)
2,4-Dichlorophenoxy acetic acid	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13
Endrin	0.02
Heptachlor (and its epoxide)	0.008
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-Trichlorophenoxy acetic acid (Silvex)	1.0
Vinyl chloride	0.2

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264), Subpart B, General Facility Standards	Hazardous waste treatment, storage, or disposal	General requirements are established for locating and inspecting treatment, storage, and disposal facilities for hazardous waste; determining waste compatibility; and training workers. Location requirements include (1) facilities should not be located within 61 m (200 ft) of a fault in which displacement has occurred in Holocene time (i.e., since the end of the Pleistocene) and (2) facilities located in a 100-year floodplain should be constructed, operated, and maintained to prevent washout of any waste by a 100-year flood.	Potentially applicable/ relevant and appropriate	Certain of these requirements would be applicable to the treatment or storage of site waste that meets the prerequisites for definition as hazardous waste. The substantive treatment and storage requirements are being addressed for on-site areas designated as temporary hazardous waste facilities, e.g., Building 434 and the TSA. These temporary facilities and the conceptual locations of an on-site treatment facility and disposal cell are not within the established distance to such a fault displacement or in a 100-year floodplain. The treatment facility requirements would be applicable to the characteristic hazardous waste, but the disposal facility requirements would not because such waste would have been treated so that it no longer met the definition of hazardous waste (i.e., it would no longer exhibit the characteristic). These requirements would be applicable if listed waste were disposed of on-site, but no listed waste has been identified. However, even if site waste did not meet the prerequisites for definition as hazardous waste, the location-specific requirements could be considered relevant and appropriate on the basis of sufficient similarity of the waste and purpose of the requirement.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264), Subpart C, Preparedness and Prevention; Subpart D, Contingency Plan and Emergency Procedures	Hazardous waste treatment, storage, or disposal	Treatment, storage, and disposal facilities for hazardous waste should be designed, constructed, maintained, and operated to minimize the possibility of a fire, explosion, or any unplanned sudden or nonsudden release of hazardous waste (or constituents) to air or water that could threaten human health or the environment. A contingency plan should be in place and emergency procedures should be implemented to minimize releases of hazardous waste from such a facility.	Potentially applicable/ relevant and appropriate	These requirements would be applicable to the treatment or storage of site waste that meets the prerequisites for definition as hazardous waste. The substantive treatment and storage requirements are being addressed for on-site areas designated as temporary hazardous waste facilities (e.g., Building 434 and the TSA). The disposal requirements would be applicable if listed waste were disposed of on-site, but no listed waste has been identified. After treatment of the characteristic waste, the disposal requirements would not be applicable because the waste would no longer meet the definition of hazardous waste. However, even if site waste did not meet the prerequisites for definition as hazardous waste, certain requirements could be considered relevant and appropriate on the basis of sufficient similarity. (The contingency plan would not be an ARAR for an on-site action because it would constitute an administrative requirement at a CERCLA site; nevertheless, such a plan would be prepared as part of good management practice for the project.)

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264), Subpart E, Manifest System, Recordkeeping, and Reporting	Hazardous waste treatment, storage, or disposal	Various administrative requirements are established for treatment, storage, and disposal of hazardous wastes.	Potentially applicable/ not an ARAR	These requirements would be applicable if site waste that meets the prerequisites for definition as hazardous waste was treated, stored, or disposed of in an off-site facility. The off-site transport of specific liquid waste, e.g., to a permitted incinerator, would be conducted in accordance with pertinent requirements (see discussion of transportation requirements in this table). If the waste was treated, stored, or disposed of in an on-site facility, these requirements would be neither applicable nor relevant and appropriate because they constitute administrative requirements for an on-site CERCLA action. Nevertheless, various administrative requirements are currently being addressed for on-site areas designated as temporary hazardous waste facilities, e.g., Building 434 and the TSA, and they would continue to be addressed as appropriate for the action.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart F, Releases from Solid Waste Management Units	Hazardous waste disposal	A groundwater monitoring system should be maintained for a hazardous waste management unit such as a surface impoundment, waste pile, land treatment unit, or landfill. An exemption to continued maintenance of this system during the post-closure period of the unit may be appropriate if the unit is an engineered structure; does not receive or contain liquid waste or waste-containing free liquid; is designed and operated to exclude liquid, precipitation, and other run-on and runoff; has both an inner and outer containment layer with a leak detection system; is maintained to disallow migration beyond the outer containment layer before the post-closure care period; and monitoring results do not identify a statistically significant increase in hazardous constituents in the upper aquifer during the operational life of the impoundment. Where multiple regulated units are present at a facility, the point of compliance for this monitoring can be taken as the circumscription of all of these units. The concentration of a hazardous constituent in the uppermost aquifer beneath a regulated unit is not to exceed the existing background concentration or the maximum concentration listed in the following table if higher than the background level, or an alternate concentration limit, unless an exemption is appropriate.	Potentially applicable/ relevant and appropriate	These requirements would be applicable if listed waste were disposed of on-site, but no listed waste has been identified. After treatment of the characteristic waste, these requirements would not be applicable to disposal because the waste would no longer meet the definition of hazardous waste. However, even if site waste did not meet the prerequisites for definition as hazardous waste, certain requirements could be considered relevant and appropriate on the basis of sufficient similarity. (For CERCLA actions, the point of compliance for multiple sources in close geographical proximity can be taken as the circumscription of all such sources. For the current remedial action, this circumscription would encompass the entire former ordnance works facility, which includes both the Weldon Spring site and the adjacent Army NPL site.)

Constituent	Concentration (µg/L)
Arsenic	50
Barium	1,000
Cadmium	10
Chromium	50
Lead	50
Mercury	2
Selenium	10
Silver	50

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264), Subpart G, Closure and Post-Closure	Closure of hazardous waste facilities	A waste facility such as a land disposal unit should be closed in a manner that controls, minimizes, or eliminates post-closure escape of hazardous material, leachate, contaminated runoff, or hazardous waste decomposition products to groundwater, surface water, or the atmosphere to the extent necessary to protect human health and the environment. Closure plans and post-closure plans for 30-year care (including contingency plans for surface impoundments and waste piles) should be developed for hazardous waste facilities; survey plats should be prepared to identify the locations of disposal unit(s) and permanent benchmarks, with a note regarding the operator's obligation to restrict disturbance of the disposal unit. Other administrative requirements are also identified.	Potentially applicable/ relevant and appropriate	Certain of these requirements would be applicable to units that are used to manage hazardous wastes for treatment or storage, and the substantive requirements would be addressed for the closure of such facilities. They would also be applicable for disposal units if listed waste were disposed of on-site, but no listed waste has yet been identified. After treatment of the characteristic waste, these requirements would not be applicable to disposal because the waste would no longer meet the definition of hazardous waste. However, even if site waste did not meet the prerequisites for definition as hazardous waste, certain requirements could be considered relevant and appropriate on the basis of sufficient similarity. (The preparation of plans and other administrative requirements would not be ARARs for an on-site action because they constitute administrative requirements at a CERCLA site; nevertheless, the substantive components of such plans would be addressed as part of good management practice for the project.)

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264), Subpart H, Financial Requirements	Hazardous waste treatment, storage, or disposal	General financial requirements are established for owners and operators of hazardous waste facilities, including storage facilities.	Potentially applicable/ not an ARAR	These requirements would be applicable, i.e., for the owner/ operator of a commercial facility if site waste that meets the prerequisites for definition as hazardous waste was treated, stored, or disposed of in such a facility. If the waste were treated, stored, or disposed of in an on-site facility, these requirements would be neither applicable nor relevant and appropriate because the federal government is specifically exempted from them.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264), Subpart I, Use and Management of Containers	Hazardous waste storage	Containers used to store hazardous waste should be closed and in good condition. The storage facility for hazardous waste should include a containment system with an impervious base designed and operated to drain liquid that could result from leaks, spills, or precipitation, unless containers are located such that they would not contact accumulated liquid. The containment system should have sufficient capacity to contain 10% of the volume of the containers or the volume of the largest container, whichever is greater (containers that do not contain free liquid need not be considered in this determination). The facility should also contain a collection area for drained liquid and a runon prevention system, unless the collection system has sufficient excess capacity to contain any runon. Storage areas with containers holding only wastes that do not contain free liquids do not require such a system, provided that the area is designed to drain and remove liquids from precipitation or that containers are protected from contact with liquids. Incompatible wastes should be separated, and weekly inspections should be made. Upon closure, all hazardous waste should be removed from the containment system, as should remaining containers, liners, bases, and soil contaminated with the waste or waste residues.	Potentially applicable/ relevant and appropriate	These requirements would be applicable for site waste that meets the prerequisites for definition as hazardous waste (no listed waste has been identified). The substantive requirements have been addressed for the design, construction, and operation of temporary storage facilities, such as Building 434 and the TSA, and they would also be addressed for their closure. For site waste that did not meet the prerequisites for definition as hazardous waste, these requirements could be considered relevant and appropriate on the basis of sufficient similarity.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264); Subpart J, Tank Systems	Management and closure of hazardous waste tanks	Tank systems used to store or treat hazardous waste should have sufficient strength, spill and overfill prevention, and corrosion protection, and they should be inspected regularly. Such systems should also have a secondary containment system (e.g., a double wall, external liner, vault, or equivalent) designed, installed, and operated to prevent migration of wastes or accumulated liquid out of the system and capable of detecting and collecting releases until the collected material is removed. The secondary containment system should consist of material compatible with the wastes and of sufficient strength and thickness to prevent failure from pressure gradients, physical contact with wastes, climatic conditions, and daily operations. Closure plans should be prepared, and system components, waste residues, and contaminated soil should be removed or decontaminated upon closure.	Potentially applicable/ relevant and appropriate	These requirements would be applicable to the treatment or storage of site waste that meets the prerequisites for definition as hazardous waste. The substantive treatment and storage requirements are being addressed for on-site tanks (e.g., the tributyl phosphate tanks), and closure requirements would be similarly addressed. For site waste that did not meet the prerequisites for definition as hazardous waste, certain requirements could be considered relevant and appropriate on the basis of sufficient similarity. (The requirement for preparing closure plans would not be an ARAR for an on-site action because it constitutes an administrative requirement at a CERCLA site; nevertheless, the substantive components of such plans would be addressed as part of good management practice for the project.)

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264 as amended by 57 Federal Register 3462), Subpart K, Surface Impoundments	Hazardous waste treatment, storage, or disposal	Unless an exemption for an equivalent design and operation is appropriate, a surface impoundment should contain (1) a composite double liner designed to prevent failure due to pressure gradients, waste contact, climatic conditions, or stress from installation/operation; the liner must contain both an upper membrane liner and a bottom composite liner consisting of a geomembrane underlain by at least 3 ft of recompacted clay or other natural material with a permeability of $\leq 10^{-7}$ cm/s (or equivalent); (2) a leachate collection system between the liners and a leak detection system; and (3) a base capable of supporting the liner to prevent failure due to settlement, compression, or uplift. The leak detection system should have a bottom slope of at least 1% and meet minimum design criteria for thickness and hydraulic transmissivity, depending on the material used (synthetic drainage material or granular material). In addition, the impoundment should include dikes and other controls to prevent overtopping, overfilling, wind dispersal, rainfall, and runon. The impoundment should be inspected weekly and after storms during operation, and closure and contingency plans should be developed. Upon closure, system components, waste residues, and contaminated subsoils should be removed, or remaining waste should be solidified and stabilized to a bearing capacity sufficient to support a final cover designed and constructed to (1) have a permeability not to exceed that of the bottom liner system; (2) promote drainage and minimize erosion or abrasion of the cover; (3) minimize long-term migration of liquids through the impoundment; (4) accommodate settling and subsidence; and (5) function with minimum maintenance. The integrity of the impoundment should be monitored and maintained, e.g., runon/runoff should be prevented from damaging the cover, and a groundwater monitoring system should be maintained (see the previous discussion of Subpart F in this table).	Potentially applicable/ relevant and appropriate	These requirements would be applicable to the treatment or storage units if the site waste meets the prerequisites for definition as hazardous waste. These requirements would be applicable if listed waste were managed on-site, but no listed waste has been identified. After treatment of the characteristic waste, the disposal requirements would not be applicable because the waste would no longer meet the definition of hazardous waste. However, even if site waste did not meet the prerequisites for definition as hazardous waste, certain requirements could be considered relevant and appropriate on the basis of sufficient similarity.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264 as amended by 57 Federal Register 3462), Subpart L, Waste Piles	Hazardous waste storage	Requirements are established for the design, construction, operation, and closure of waste piles used to store hazardous waste. Hazardous waste piles not inside or under a structure providing protection from precipitation, runon, leachate generation, and wind dispersal should be designed and operated as follows. Piles that could be subject to wind dispersal should be covered or otherwise managed. Unless an exemption for an equivalent design and operation is appropriate, the pile should contain (1) a composite double liner designed to prevent failure due to pressure gradients, waste contact, climatic conditions, or stress from installation/operation; (2) a leachate collection and removal system above the liner to ensure that the leachate depth over the liner does not exceed 1 ft, designed and constructed to prevent collapse and function without clogging; and (3) a base capable of supporting the liner to prevent failure because of settlement, compressions, or uplift. In addition, the pile should include runon and runoff control systems to address the peak discharge from a 25-year storm and a 24-hour, 25-year storm, respectively. The pile should be inspected weekly and after storms during operation, and closure plans and contingent post-closure plans should be developed. Upon closure, system components, waste residues, and contaminated subsoils should be removed. If, after removing all residues and making all reasonable efforts to remove or decontaminate contaminated components, subsoils, structures, and equipment, not all subsoils can be practicably removed, the facility should be closed in accordance with the closure and post-closure care requirements that apply to landfills (see discussion of Subpart N in this table).	Potentially applicable/ relevant and appropriate	These requirements would be applicable if site waste that meets the prerequisites for definition as hazardous waste (no listed waste has been identified) was stored in a waste pile. In this case, the pertinent requirements would be addressed. If site waste did not meet the prerequisites for definition as hazardous waste, certain requirements could be considered relevant and appropriate on the basis of sufficient similarity.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart M, Land Treatment	Hazardous waste treatment	Various requirements are identified for (1) prior demonstration of treatment effectiveness; (2) location, depth, and monitoring of the treatment zone; (3) runon/runoff control systems and wind dispersal control; and (4) closure and post-closure care.	Not an ARAR	These requirements would be neither applicable nor relevant and appropriate to the remedial action because land treatment is not a component of the action.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264 as amended by 57 Federal Register 3462), Subpart N, Landfills	Hazardous waste disposal	Liquids should not be placed in a landfill, nor should containers holding free liquids unless all free-standing liquid has been removed, mixed with absorbent or solidified, or otherwise eliminated. Requirements for design, construction, and operation of new landfill units are similar to those described for surface impoundments, including requirements for the liner, inspection and monitoring during operations, and closure and post-closure care (see discussion of Subpart K in this table).	Potentially applicable/ relevant and appropriate/ not an ARAR	The preliminary determination varies, depending on the specific application of these requirements. These requirements would be applicable if listed waste were disposed of on-site, but no listed waste has been identified. After treatment of the characteristic waste, the disposal requirements would not be applicable because such waste would no longer meet the definition of hazardous waste. However, even if site waste did not meet the prerequisites for definition as hazardous waste, certain requirements could be considered relevant and appropriate on the basis of sufficient similarity and purpose. However, for the chemical stabilization/ solidification alternative, the free-standing liquid requirement would be relevant but not appropriate because of the nature of the treated waste. If it were not handled wet through placement in the cell (where it would subsequently solidify), this waste would be susceptible to radon and particulate emissions that could pose a significant health threat to workers. In addition, emplacing the material in a wet form would allow it to move into openings in the other waste, minimizing the total disposal volume; this alternate method would also increase the overall density of the final waste form, thereby improving the structural integrity of the cell compared with the indicated method.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart O, Incinerators	Hazardous waste incineration	Hazardous waste to be incinerated should be analyzed for principal organic hazardous constituents, and the incinerator should be operated to meet a destruction removal efficiency of 99.99% for each principal organic hazardous constituent listed for the action and a destruction removal efficiency of 99.9999% for certain listed waste containing chlorinated phenol and benzene compounds. If the incinerator emits >1.8 kg/h of hydrogen chloride (HCl) from the stack, emissions should be controlled to the larger of this rate or 1% of the HCl in the stack gas prior to encountering pollution control equipment; in addition, the incinerator should not emit particulate matter in excess of 180 mg/m^3 air (corrected for oxygen). The incinerator should be permitted, and trial burns should be conducted to assess effectiveness; permitted conditions would address the following: feed rate, combustion temperature, fugitive emission controls, and the level of carbon monoxide in the exhaust gas. Frequent monitoring and inspection would also be required, and, upon closure, all hazardous waste and residues should be removed.	Potentially applicable/ relevant and appropriate	These requirements would be applicable if site waste that meets the prerequisites for definition as hazardous waste (no listed waste has been identified), such as a liquid containing chlorinated organic compounds, was incinerated. Even if site waste did not meet the prerequisites for definition as hazardous waste, certain requirements could be considered relevant and appropriate on the basis of sufficient similarity. If the waste were incinerated at an off-site facility, these requirements would apply at that facility. If the incinerator were located on-site, a permit would not be required because the action would constitute an on-site CERCLA action; however, the substantive requirements of such a permit would be addressed. The requirements could also be considered relevant and appropriate to the vitrification alternatives because vitrification might be considered somewhat similar to an incinerator, in which case the pertinent requirements would be addressed.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Wastes (40 CFR 264), Subpart X, Miscellaneous Units	Hazardous waste treatment, storage, or disposal	The location, design, construction, operation, maintenance, closure, monitoring, inspection, and post-closure of miscellaneous hazardous waste units should be conducted in a manner that ensures protection of human health and the environment.	Potentially applicable/ relevant and appropriate	These requirements would be applicable if site waste that meets the prerequisites for definition as hazardous waste (no listed waste has been identified) was placed in such miscellaneous units. In this case, the pertinent requirements would be addressed. Even if site waste did not meet the prerequisites for definition of hazardous waste, certain requirements could be considered relevant and appropriate on the basis of sufficient similarity.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Solid Waste (40 CFR 264), Subpart AA, Air Emission Standards for Process Vents	Hazardous waste treatment, storage, or disposal	Emissions requirements for process vents associated with distillation, fractionation, thin film evaporation, solvent extraction, or air or steam stripping operations that manage hazardous wastes with organic concentrations of at least 10 ppmw (parts per million by weight) are specified.	Not an ARAR	These requirements are not ARARs because none of the listed processes is a component of the action.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901 et seq.); Solid Wastes (40 CFR 264), Subpart BB, Air Emission Standards for Equipment Leaks	Hazardous waste treatment, storage, or disposal	Emission standards for equipment leaks from pumps, compressors, pressure relief devices, sampling connecting systems, and valves are specified. These apply to equipment that contains or contacts hazardous wastes with organic concentrations of at least 10% by weight that are managed in units subject to the permitting requirements of 40 CFR 270.	Not an ARAR	These requirements are not ARARs for an on-site action because any such equipment would not be subject to the indicated permitting requirements (these constitute administrative requirements at a CERCLA site) and the site waste does not contain the indicated organic concentrations so conditions would not be considered sufficiently similar to be relevant and appropriate.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities (40 CFR 266), Subpart H, Hazardous Waste Burned in Boilers and Industrial Furnaces	Burning of hazardous waste	Standards to control emissions of organic compounds, particulate matter, metals, and hydrogen chloride (HCl) and chlorine gas (Cl_2) are specified as follows. A boiler or industrial furnace burning hazardous waste should achieve a destruction and removal efficiency of 99.99% for all organic hazardous constituents in the waste feed. Products of incomplete combustion are regulated by a carbon monoxide (CO) emission standard that requires concentrations in the off-gas to be less than 100 ppmv (parts per million by volume) on an hourly rolling average basis continuously corrected to 7% oxygen, dry gas basis. These limits can be waived if the total hydrocarbon (HC) concentration in the stack gas does not exceed 20 ppmv on an hourly rolling average basis, reported as propane and continuously corrected to 7% oxygen, dry gas basis. A boiler or industrial furnace burning hazardous waste should not emit particulate matter in excess of 180 mg/m^3 (dry) after correction to a stack gas concentration of 7% oxygen. If the screening limits for feed and emission rates of metals, HCl, and Cl_2 are exceeded, the operator must demonstrate compliance with reference air concentrations for noncarcinogenic metals, HCl, and Cl_2 (identified in the following table) and with a 10^{-5} risk level for carcinogenic metals using dispersion modeling. Screening limits are a function of effective stack height, land use, and terrain and are presented in the following table for a 40-m effective stack height for noncomplex terrain in rural areas.	Potentially relevant and appropriate	These requirements would not be applicable because no hazardous waste would be burned or processed in a boiler or industrial furnace as a component of the remedial action. However, certain requirements could be considered relevant and appropriate for the vitrification alternatives because vitrification might be considered somewhat similar to an industrial furnace (a melting furnace); in this case, the pertinent requirements would be addressed.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
(Cont.)				

Contaminant	Screening Limit[a] (g/h)
Metals[b]	
Antimony	1,100
Arsenic	8.2
Barium	180,000
Beryllium	15
Cadmium	20
Chromium	3.0
Lead	320
Mercury	1,100
Silver	11,000
Thallium	1,100
Chlorine and HCl[c]	
Cl_2	1,400[d]
HCl	25,000[e]

[a] Limits are both feed rate limits and emission rate limits, unless otherwise noted.

[b] Reference air concentrations are 0.3, 50, 0.09, 0.3, 3, and 0.5 $\mu g/m^3$ for antimony, barium, lead, mercury, silver, and thallium, respectively.

[c] Reference air concentrations for Cl_2 and HCl are 0.4 and 7 $\mu g/m^3$, respectively.

[d] Feed rate and emission rate screening limits as total and free chlorine, respectively.

[e] Emission rate screening limit.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Land Disposal Restrictions (40 CFR 268), Subpart A, General	Hazardous waste treatment and disposal	Identified hazardous wastes are restricted from land disposal except in specific circumstances. Wastes that are otherwise restricted from land disposal may be treated in surface impoundments subject to specified conditions. An extension to the effective date of any applicable restriction can be applied for, as can an exemption. For the latter, a petition is to be submitted to EPA demonstrating that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous. Waivers can apply. Characteristic hazardous waste that is treated to comply with the treatment standards in Subpart D (see later entry in this table) may be land disposed. A restricted waste should not be diluted to meet those standards.	Potentially applicable/ not an ARAR	These requirements would be applicable if listed waste were disposed of on-site, but no listed waste has been identified. These requirements would be applicable to the treatment of characteristic hazardous waste in order to meet the treatment standards for disposal. After treatment, these requirements would be neither applicable nor relevant and appropriate to the disposal of this waste because the waste would no longer meet the definition of hazardous waste. That is, if site waste did not meet the prerequisites for definition as a hazardous waste, these requirements would not be an ARAR.
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Land Disposal Restrictions (40 CFR 268), Subpart C, Prohibitions on Land Disposal	Hazardous waste treatment and disposal	The land disposal of certain hazardous waste (such as liquid waste containing ≥50 ppm PCBs) is prohibited unless the waste or waste extract meets the treatment standards of Subpart D (see next entry) or an exemption has been granted. Treatment should attain the treatment standards identified for each hazardous constituent in the waste for which a treatment standard exists.	Potentially applicable/ not an ARAR	These requirements would be applicable if listed waste were disposed of on-site, but no listed waste has been identified. These requirements would be applicable to the treatment of characteristic hazardous waste in order to meet the treatment standards for disposal. After treatment, these requirements would be neither applicable nor relevant and appropriate to the disposal of this waste because the waste would no longer meet the definition of hazardous waste. That is, if site waste did not meet the prerequisites for definition as hazardous waste, these requirements would not be an ARAR.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Land Disposal Restrictions (40 CFR 268), Subpart D, Treatment Standards	Hazardous waste treatment and disposal	A restricted waste identified in Subpart C of 40 CFR 268 may be land disposed only if (1) an extract of the waste or of the treatment residue of the waste does not exceed the values identified for any hazardous constituent for that waste, (2) the restricted waste is treated with the specified technology or an equivalent EPA-approved method, or (3) the constituent concentrations in the waste or treatment residue of the waste do not exceed specified values for any hazardous constituent for that waste, as applicable. Where the treatment standard is expressed as a concentration in a waste or waste extract and a waste cannot be treated to the specified level, or where the treatment technology is not appropriate to the waste, the generator may petition the EPA for a variance from the treatment standard by demonstrating that the physical or chemical properties of the waste differ significantly from the waste that was analyzed to develop the treatment standard.	Potentially applicable/ not an ARAR	These requirements would be applicable to the treatment of characteristic waste so that it would no longer meet the prerequisites for definition as hazardous waste. These requirements would also be applicable for waste disposal if listed waste were to be disposed of at the site, but no such waste has yet been identified. If these requirements were applicable, the contaminated soil and debris resulting from the action would not be sufficiently similar to that for which the treatment standards were developed under this act. In addition, a given treatment technology has not been demonstrated for this specific material. Furthermore, a technology such as incineration, which is specified as the treatment technology for certain contaminants, might in fact be inappropriate for site waste because of the presence of other contaminants in the large volume of variable material that could be released (e.g., mercury is present in the raffinate pit sludge). Therefore, this material would qualify for the treatability variance, and the action would comply with the land disposal restrictions through this variance. If site waste did not meet the prerequisites for definition as hazardous waste, these requirements would not be an ARAR.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Solid Waste Disposal Act, as amended (42 USC 6901, et seq.); Land Disposal Restrictions for Newly Listed Wastes and Contaminated Debris (57 Federal Register 958), Proposed Rule	Disposal of debris contaminated with hazardous waste	Debris that contains a hazardous waste listed in Subpart D of 40 CFR 261 for which land disposal restrictions have been promulgated, or that exhibits characteristics of hazardous waste in Subpart C of 40 CFR 261 for which land disposal restrictions have been promulgated, should be treated prior to land disposal using specific technologies from one or more families of debris treatment technologies (extraction, destruction, or immobilization). This treatment should be performed in accordance with specified performance standards. Treated debris would no longer be prohibited from land disposal and would not require management as a hazardous waste if a destruction or extraction technology were used for all debris types and contaminant combinations, provided that it did not exhibit a hazardous waste characteristic. Residuals from treatment are subject to F039 (multisource leachate wastewater and nonwastewater) numerical treatment standards, which are identified below for selected contaminants. The treatment unit would be subject to the standards in 40 CFR 264 and 265 for treatment facilities to ensure protection of human health and the environment. Mixed waste debris should comply with the rules for contaminated debris in addition to those under the Atomic Energy Act.	To be considered/ not an ARAR	Because this is not a promulgated standard, it is addressed as a "to be considered" requirement. The proposed rule would be considered for management of contaminated debris if the site waste met the prerequisites for definition as hazardous waste. Otherwise, this would not be a TBC (or ARAR, if promulgated).

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks

(Cont.)

Constituent	Nonwastewater[a] (mg/L, except as noted)	Wastewater[b] (mg/L)
Antimony	0.23	1.9
Arsenic	5.0	1.4
Barium	52	1.2
Beryllium	NA[c]	0.82
Cadmium	0.066	0.20
Chromium (total)	5.2	0.37
Copper	NA	1.3
Lead	0.51	0.28
Mercury	0.025	0.15
Nickel	0.32	0.55
Selenium	5.7	0.82
Silver	0.072	0.29
Thallium	NA	1.4
Vanadium	NA	0.042
Zinc	NA	1.0
2,4-Dinitrotoluene	140[d]	0.32
2,6-Dinitrotoluene	28[d]	0.55
Nitrobenzene	14[d]	0.068

[a] Concentration in the waste extract, except for 2,4-dinitrotoluene, 2,6-dinitrotoluene, and nitrobenzene, for which the concentration in the waste is listed.

[b] Concentration in the wastewater.

[c] NA means that no numerical standard is available for a concentration in the waste extract for this constituent.

[d] Concentration in the waste, in mg/kg.

TABLE G.3 (Cont.)

Citation	Action	Requirement	Preliminary Determination	Remarks
Missouri Hazardous Substance Rules (10 CSR 24); Missouri Solid Waste Management Law (RSMo. 260.200 to 260.245) and Regulations (10 CSR 80); Missouri Hazardous Waste Management Law (RSMo. 260.350 to 260.552) and Regulations (10 CSR 25)	Hazardous waste treatment, storage, or disposal	The owner/operator of a hazardous waste treatment, storage, or disposal facility should comply with the following requirements, in addition to those of 40 CFR 264 (see related discussion in this table); in the case of contradictory or conflicting requirements, the more stringent would control. Hazardous waste landfills should be located such that potential discharges and harm to human health and the environment are minimized; such landfills should not be located in an area of unstable soil deposits subject to landslides or catastrophic collapse. All new hazardous waste landfills should be constructed with double liners, a leachate collection system above the top liner, a leak detection system between liners, and a base as outlined in 40 CFR 264, Subpart N (see discussion in this table). The permeability of each detection or collection system should exceed 10^{-2} cm/s, and at least 30 ft of soil or other material with a permeability of less than 10^{-7} cm/s should be present between the bottom of the lowest liner and the uppermost regional aquifer, or an equivalent protection may be based on at least 20 ft of naturally occurring material for such a landfill that receives only waste generated by its operator. Groundwater should also be monitored beyond the property boundary.	Potentially applicable/ relevant and appropriate	These requirements would be applicable to the treatment or storage of site waste that meets the prerequisites for definition as hazardous waste. The substantive requirements are being addressed for areas designated as temporary hazardous waste facilities (e.g., Building 434 and the TSA). The disposal requirements would be applicable if listed waste were disposed of on-site, but no listed waste has been identified. After treatment of the characteristic waste, the disposal requirements would not be applicable because such waste would no longer meet the definition of hazardous waste. However, on the basis of sufficient similarity of the regulated conditions, certain requirements for siting, buffer zone, and cell cover and liner could be relevant and appropriate to the location and design of the disposal cell for an on-site action. The requirements for overburden thickness and permeability would be relevant but not appropriate because of the specific circumstances at the chemical plant facility.

G.3 REFERENCES (APPENDIX G)

MacDonell, M.M., et al., 1990, *Engineering Evaluation/Cost Analysis for the Proposed Management of Contaminated Water Impounded at the Weldon Spring Chemical Plant Area*, DOE/OR/21548-106, prepared by Argonne National Laboratory, Environmental Assessment and Information Sciences Division, Argonne, Ill., for U.S. Department of Energy, Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project, St. Charles, Mo., July.

U.S. Department of Energy, 1992a, *Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site*, DOE/OR/21548-091, prepared by Argonne National Laboratory, Environmental Assessment and Information Sciences Division, Argonne, Ill., for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, St. Charles, Mo., Nov.

U.S. Department of Energy, 1992b, *Proposed Plan for Remedial Action at the Chemical Plant Area of the Weldon Spring Site*, DOE/OR/21548-160, prepared by Argonne National Laboratory, Environmental Assessment and Information Sciences Division, Argonne, Ill., for U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, St. Charles, Mo., Nov.

U.S. Environmental Protection Agency, 1990, *National Oil and Hazardous Substances Pollution Contingency Plan; Final Rule (40 CFR Part 300)*, Federal Register, 55(46):8666-8865, March 8.

APPENDIX H:

FLOODPLAIN/WETLAND ASSESSMENT FOR THE REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE

APPENDIX H:

FLOODPLAIN/WETLAND ASSESSMENT FOR THE REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE

H.1 PROJECT PURPOSE AND DESCRIPTION

The purpose and description of the Weldon Spring Site Remedial Action Project are discussed in Chapter 1 of this feasibility study (FS). Cleanup of the site may entail the excavation, treatment, and disposal of approximately 519,000 m^3 (679,000 yd^3) of contaminated sludge, sediment, and soil from a number of on-site and off-site locations (Chapter 1, Figures 1.3 and 1.4). Alternative options being evaluated for the disposal of the contaminated media include the construction of a disposal cell at (1) the chemical plant area of Weldon Spring site, (2) Envirocare of Utah, Inc., a commercial facility located near Clive, Utah, or (3) the 200-West Area at the U.S. Department of Energy (DOE) Hanford site near Richland, Washington. In the event that off–site disposal is selected, a dedicated rail siding may be constructed near the town of Wentzville, Missouri, from which treated and untreated contaminated materials would be shipped by rail to the disposal cell location.

Construction and/or backfill activities associated with the different alternatives are estimated to require up to about 1.16 million m^3 (1.52 million yd^3) of clean, uncontaminated borrow (fill) material. Of this amount, DOE might obtain up to 895,000 m^3 (1.17 million yd^3) from a nearby source, potentially from a 61-ha (150-acre) tract located in the Weldon Spring Wildlife Area, approximately 1.5 km (1.2 mi) east of the chemical plant area (Chapter 5, Figure 5.1). The remaining borrow material would be supplied by local vendors. On the basis of current conceptual plans, approximately 34 ha (85 acres) would be disturbed by excavation and construction activities. About 21 ha (52 acres) could be excavated to an average depth of 4.3 m (14 ft) for borrow material.

The excavation and construction activities proposed for the remediation of the Weldon Spring site could adversely impact wetland and floodplain areas. The DOE is committed to avoiding or minimizing adverse impacts to floodplains and wetlands from its activities to the extent possible (Title 10, Code of Federal Regulations, Part 1022 [10 CFR 1022]), and all remedial activities at the Weldon Spring site are being conducted in compliance with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands. The assessment presented in this appendix addresses the potential for floodplain and wetland impacts that might occur as a result of the proposed removal of contaminated sediment and soil from the Weldon Spring site and selected off-site locations, the construction of a rail siding off-site, and the construction of a disposal cell at an on-site or off-site location.

This assessment does not address floodplain or wetland issues associated with activities at the Southeast Drainage; Lakes 34, 35, and 36; Femme Osage Slough and vicinity property B9; or the proposed borrow area. The Southeast Drainage is a natural drainage channel located southeast of the site (Chapter 1, Figure 1.4) that contains contaminated sediment, soil, and

surface water (intermittently). Contaminated surface water, sediment, and soil are also present in portions of Lakes 34, 35, and 36 in the August A. Busch Memorial Wildlife Area. Femme Osage Slough is a small portion of Femme Osage Creek that was cut off from its original channel by a levee constructed in 1959 and 1960. The slough, located south of the Weldon Spring quarry (Chapter 1, Figure 1.4), contains contaminated surface water and sediment. Vicinity property B9 is located adjacent to the slough and contains contaminated soil.

The Southeast Drainage is being treated as a separate response action, in part because additional characterization is needed for the drainage and also because conditions in the drainage will change as a result of cleanup activities at the chemical plant area. The drainage will be addressed as a separate removal action within the next several years, and a floodplain/wetland assessment and other documentation will be prepared to support related decisions.

Lakes 34, 35, and 36 will be addressed in conjunction with sedimentation management activities that the Missouri Department of Conservation has scheduled for these lakes (Dieffenbach 1992). The sedimentation management program addresses the problem of reservoir siltation and also provides for maintenance of the reservoir dams. In this program, a lake targeted for renovation is drained and the accumulated sediment is excavated; the lake is then refilled and restocked with fish. To remediate Lakes 34, 35, 36, DOE will remove contaminated sediment and shoreline soil after the state has drained the lakes. Following removal of the contaminated sediment and soil by DOE, the state will complete sediment removal, refill the lakes, and restore the habitats and biota. A floodplain/wetland assessment may be prepared in the future when the Missouri Department of Conservation begins its renovation activities at Lakes 34, 35, and 36. The impacts associated with the removal of the contaminated sediment and soil from these lakes by DOE are expected to be identical to the impacts that would be incurred by the scheduled state renovation activities alone. Because the contaminated areas are only part of the entire area that will be drained and excavated, impacts would be bounded by those associated with the state activities. The overall purpose of these activities is to improve the conditions at these lakes.

Femme Osage Slough and vicinity property B9 will be addressed during the follow-on decision-making process for the quarry residuals operable unit (Section 1.5.3). A remedial investigation/feasibility study (RI/FS) work plan is being prepared for these, and a floodplain/wetland assessment will be included with the planned RI/FS. This document package will incorporate National Environmental Policy Act (NEPA) values in accordance with the level of analysis for an environmental assessment (EA).

A source of borrow soil is needed to support backfill and construction activities planned for the current stage of site cleanup. A potential location for this material has been identified and evaluated as the representative borrow area for the analysis in this FS. In the event that this potential borrow area is selected as the source of clean soil for use at the chemical plant area, an EA would be prepared to address potential impacts from excavation and other activities. Potential impacts to wetlands from these activities would be evaluated in a wetlands assessment, which would be included in the EA.

H.2 FLOODPLAIN AND WETLAND EFFECTS

Various sources of information were used to identify the occurrence of floodplains or wetlands at the Weldon Spring site and at the proposed rail siding, borrow area, and disposal cell locations. These include National Wetlands Inventory Maps (U.S. Fish and Wildlife Service 1989a, 1989b, 1989c), Flood Insurance Rate Maps for St. Charles County (Federal Insurance Administration 1978a, 1978b, 1978c), environmental characterization reports for the Hanford facility in Washington and the Envirocare facility in Utah (DOE 1984; Pacific Northwest Laboratory 1991), and site visits by ecologists from Argonne National Laboratory.

H.2.1 Description of Floodplains

No 100-year floodplains occur at the areas proposed for the location of a disposal cell at either the Weldon Spring site (Federal Insurance Administration 1978a), the Envirocare facility (DOE 1984), or the 200-West Area of the Hanford site (Pacific Northwest Laboratory 1991). No 100-year floodplains are present at the proposed rail siding location in Wentzville (Federal Insurance Administration 1978c).

Remedial activities at the chemical plant area and the vicinity properties would disturb floodplain areas at only two locations, the portion of the Ash Pond drainage within the boundary of the chemical plant area and vicinity property A6 located on the U.S. Army Reserve and National Guard Training Area (Chapter 1, Figure 1.4). No wetlands occur in this floodplain area (U.S. Fish and Wildlife Service 1989a). Both areas occur within the 100-year floodplain of the Schote Creek-Dardenne Creek drainage basin within the headwaters of Schote Creek; they are adjacent to one another and are separated only by the Weldon Spring site property fence line (Figure H.1). Water flow at these locations is intermittent, with water typically present only during and following precipitation events. The vegetation consists of shrub and secondary growth upland and riparien forest. Tree species include oak, hickory, locust, and cottonwood. The ecological resources of the general site area, including the chemical plant area and vicinity, are described in Chapter 7 of the BA (DOE 1992a). The contamination at vicinity property A6 is located along the drainage channel from Ash Pond, and it extends approximately 200 m (660 ft) from the site fence at a width of about 3 m (10 ft) (DOE 1992b). The portion of the Ash Pond drainage channel inside the site fence that is within the 100-year floodplain is located immediately upstream of vicinity property A6 and encompasses about 0.5 ha (1.3 acres).

H.2.2 Floodplain Impacts

The removal of contaminated soil and sediment from the portion of the Ash Pond drainage within the site fence could temporarily disturb up to approximately 0.5 ha (1.3 acres) of the 100-year floodplain, whereas remediation of vicinity property A6 could temporarily disturb an additional 0.06 ha (0.15 acres). The total area that would be disturbed (<0.6 ha) represents a very small portion (<0.001%) of the entire 100-year Schote Creek-Dardenne Creek floodplain. Remedial activities in this floodplain area would consist of excavating contaminated

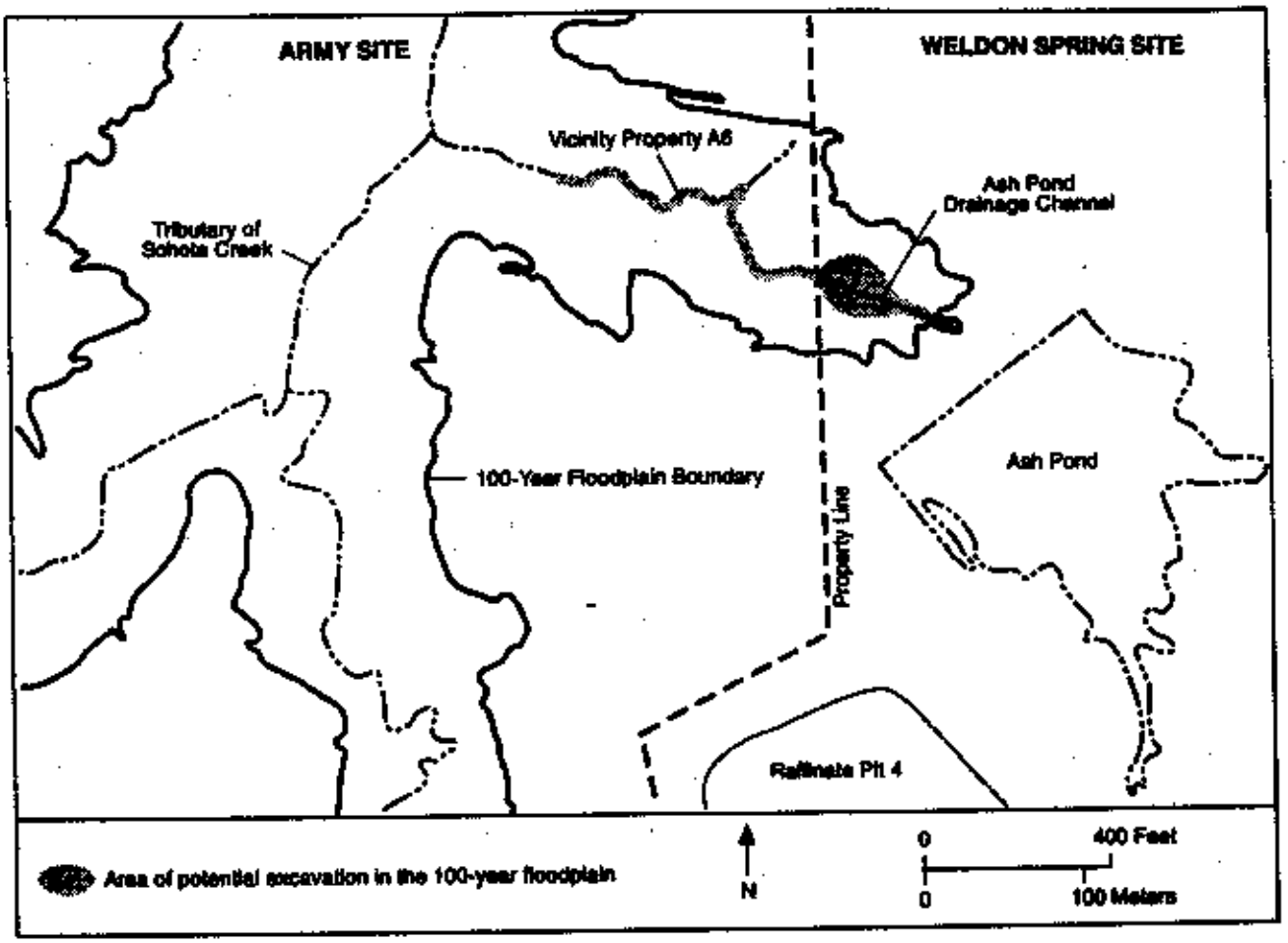

FIGURE H.1 Location of Vicinity Property A6 and the Ash Pond Drainage

soil and sediment followed by restoring of the disturbed area; no flood storage volume would be displaced by structures, access roads, or fill material. Following removal of the contaminated soil and sediment, the excavated areas would be backfilled with clean fill and graded to the extent possible to original contours. Thus, the long-term flood storage volume of the Schote Creek-Dardenne Creek floodplain would not be affected by remediation of the on-site Ash Pond drainage and vicinity property A6.

Excavating and removing contaminated soil and sediment from the floodplain could temporarily disrupt local drainage patterns; increase localized erosion, sedimentation, and contaminant transport; and destroy and displace certain biota. Impacts to vegetation and wildlife in the floodplain would not be significant. The types of old-field and forest habitats that would be disturbed are widespread throughout the Busch and Weldon Spring wildlife areas, the wildlife that would be disturbed are not unique to the area, no federal listed or Category 2 species are known to utilize the area, and no state listed species or unique natural areas are associated with the floodplain location (see Appendix I and the BA [DOE 1992a]). With appropriate mitigative measures, the temporary impacts in the floodplain would be localized and minimal. These impacts would cease upon recontouring and revegetation of the excavated portions of the floodplain, and the original flood storage volume would be restored.

H.2.3 Description of Wetlands

No wetlands are present at the areas proposed for a disposal cell at either the Envirocare or Hanford sites (DOE 1984; Envirocare 1991; Pacific Northwest Laboratory 1991; DOE 1992b). Several contaminated wetlands are present within the property boundary of the Weldon Spring site, but none of the soil vicinity properties addressed by the current remedial action contain wetlands (U.S. Fish and Wildlife Service 1989a, 1989b, 1989c). The wetlands at the chemical plant area that would be remediated under the proposed action are described in Sections H.2.3.1 and H.2.3.2.

H.2.3.1 Raffinate Pits

Raffinate pits 1, 2, and 3 cover an area of approximately 4.4 ha (9.6 acres) and are classified as excavated palustrine wetlands with unconsolidated bottoms (U.S. Fish and Wildlife Service 1989a). Raffinate pit 4 is a diked, intermittently exposed palustrine wetland with an unconsolidated bottom. This pit is the largest on-site wetland and has a surface area of approximately 6.1 ha (15 acres). The pits, which are located in the southwestern portion of the site (Chapter 1, Figure 1.3), were excavated into the existing clay soil between 1958 and 1964 for the purpose of containing radioactive and chemical process wastes from the plant; the pits currently contain about 168,000 m^3 (220,000 yd^3) of contaminated solids. The sludge in the pits is typically covered with water throughout the year; the amount of water present depends on weather conditions but averages about 216,000 m^3 (57,000,000 gal). Water is always present in pits 3 and 4, whereas in some summers raffinate pits 1 and 2 have been dry. The removal and treatment of the surface water in the raffinate pits has been discussed in past documentation supporting a separate interim action at the site (MacDonell et al. 1990).

The raffinate pits support a relatively limited biota. Little or no emergent or rooted vegetation is present, few amphibians or reptiles have been reported or collected from the pits, and electrofishing surveys have been unsuccessful in documenting the presence of fish. Spike rush (*Eleocharis* sp.) and dense stands of aquatic vegetation thought to be *Chara* sp. occur at some locations at raffinate pit 4 (Herron 1992). These impoundments are utilized by waterfowl and shorebirds, particularly during spring and autumn migrations. Killdeer and spotted sandpiper have been observed foraging in the sediment of raffinate pit 4, and more than 15 species of waterfowl have been reported on the raffinate pits (Herron 1992).

H.2.3.2 Ash Pond and Frog Pond

Ash Pond is located in the northwestern portion of the chemical plant area, at the uppermost end of an existing drainage that enters Schote Creek (Chapter 1, Figure 1.3). The drainage channel immediately below the pond is located within the 100-year floodplain, but the pond is outside the floodplain boundary. The northern third of Ash Pond (about 1.5 ha [3.7 acres]) has been classified as a diked/impounded palustrine wetland with an unconsolidated bottom (U.S. Fish and Wildlife Service 1989a). The remainder of Ash Pond (3 ha [7.4 acres]) has been classified as a diked/impounded palustrine, broad-leaved deciduous forest wetland. The

pond was constructed during the operational period of the plant to receive slurried ash discharged from the coal-fired steam plant on-site.

Prior to the construction of a dike and drainage system at the pond, standing water covering up to 4.5 ha (11 acres) would be intermittently present depending on weather conditions. Since construction of the dike and drainage system, water collects behind the dike following precipitation events. In general, the pond is dry by late summer. When present, surface water in Ash Pond is contaminated, and the pond is estimated to contain approximately 6,300 m^3 (8,200 yd^3) of contaminated sediment. The removal and treatment of surface water from Ash Pond has been previously addressed in documentation supporting a separate interim action at the site (MacDonell et al. 1990).

Frog Pond is located in the northeastern portion of the chemical plant area (Chapter 1, Figure 1.3) and is classified as an intermittently exposed, diked palustrine wetland with an unconsolidated bottom (U.S. Fish and Wildlife Service 1989a). This pond was excavated in an existing drainage during the operational period of the plant (prior to 1966) for use as a settling basin. The pond receives storm drain and surface runoff from the site. Water levels typically range from 0.3 to 1 m (1 to 3.3 ft), and, when full, the pond has a surface area of approximately 0.3 ha (0.7 acres). Frog Pond is estimated to contain approximately 5,400 m^3 (7,000 yd^3) of contaminated sediment and 2,000 m^3 (500,000 gal) of contaminated water. The removal and treatment of the surface water has been previously addressed in documentation supporting a separate interim action at the site (MacDonell et al. 1990).

Vegetation present at Ash and Frog ponds includes water smartweed, arrowhead, bull rush, cattail, smooth hedge nettle, eastern cottonwood, sycamore, and willow. Wetland vegetation surveys are currently in progress for these sites. No fish occur in Ash Pond, but small sunfish have been collected from Frog Pond (MK-Ferguson Company and Jacobs Engineering Group 1989). Wildlife reported from the Ash Pond area include wild turkey, deer, raccoon, opossum, mallard, wood duck, blue-winged teal, scaup, and Canada goose. An active raptor nest (probably red-tailed hawk) was present in the canopy at Ash Pond as recently as 1989. Ash and Frog ponds are expected to support a relatively diverse amphibian and reptile community, and the pond areas are utilized by a variety of wildlife.

H.2.4 Wetland Impacts

The wetlands at the chemical plant area would be permanently dewatered and contaminated sediment and soil would be excavated under an interim action to remove and treat contaminated water from site impoundments (MacDonell et al. 1990) in combination with the action currently being proposed. After removing this material, the areas would be filled with clean borrow material. The wetlands that would be lost at the site as a result of the proposed action total approximately 15 ha (38 acres). These wetlands represent about 6% of the total lacustrine and palustrine wetlands present in the surrounding wildlife areas, they are not unique to the area, and they did not exist prior to construction of the chemical plant. The site wetlands are a source of significant environmental contamination that pose a threat to human health,

vegetation, and wildlife. Elimination of these contaminated habitats would have a positive effect on human health and local biota.

The loss of these wetland habitats is not expected to result in significant adverse impacts to local biota. Excavation and filling of the contaminated wetlands would result in the permanent displacement or destruction of some local biota. Loss of biota would be limited to the aquatic vegetation and invertebrates (insects, crayfish, zooplankton), the fish in Frog Pond, and many or all of the amphibians and semiaquatic reptiles (e.g., turtles) that inhabit the pits and ponds. Because of the relatively limited biota inhabiting these areas and the populations present in the surrounding wildlife areas (DOE 1992a), the loss of biota from the on-site wetlands is not expected to significantly affect local populations or result in the local extinction of any species. Biota that would be permanently displaced include some amphibians, reptiles, and mammals and a variety of waterfowl and other birds.

Most of the upland (non-wetland) species occurring on-site are resident and are already present in the surrounding areas; thus, it is possible that these surrounding areas might be incapable of supporting increased numbers of these species as a result of displacement. However, the population sizes of these species in the area of the proposed action are small, so permanent loss of these individuals is not expected to adversely affect the populations on a regional basis. In addition, wetlands in the surrounding areas are probably capable of absorbing individuals displaced from the on-site wetlands and floodplains. For instance, waterfowl tend to move frequently from one wetland area to another, minimizing the likelihood of habitat saturation. Consequently, no impacts to waterfowl are anticipated to result from the temporary or permanent loss of the on-site wetlands.

No federal listed plant or animal species have been reported from the Weldon Spring site (Tieger 1988; Brabander 1990), including the Ash Pond drainage channel. The habitat types present at the vicinity property are not suitable to support federal or state listed species or state rare species that could occur in the area such as the bald eagle, Blanding's turtle, or pied-billed grebe. Two Blanding's turtles have been reported from the Busch Wildlife Area (Bedan 1991), and single individuals of the pied-billed grebe have been reported from raffinate pits 2 and 4 on-site (MK-Ferguson Company and Jacobs Engineering Group 1992). The grebe is common in the Busch Wildlife Area during the spring and fall and is rare to uncommon the rest of the year (Missouri Department of Conservation 1991). The activities at the Ash Pond drainage channel within the site fence and at vicinity property A6 are not expected to impact listed species at the Weldon Spring site or in the surrounding wildlife areas.

H.3 CONSULTATIONS AND MITIGATION

H.3.1 Floodplain Mitigative Measures

No long-term impacts to flood storage capacity are anticipated from the proposed remediation of the Ash Pond drainage and vicinity property A6. Potential short-term impacts,

resulting primarily from vegetation clearing and excavation activities, would be mitigated by using good engineering practices and implementing the following mitigative measures:

- Erosion and sediment control measures, such as berms and silt fences, would be used during all excavation, fill, and contouring activities.
- Contaminated soil and sediment would be excavated only when the Ash Pond drainage channel was dry.
- Only clean fill would be used.
- Excavated areas would be filled as soon as practicable after excavation and graded to original contours as much as possible.
- Revegetation activities would be implemented as soon as possible following recontouring of the refilled areas.

H.3.2 Wetlands Consultations and Mitigation

The DOE initiated consultations with the U.S. Department of the Army, Corps of Engineers, to determine the status of the on-site wetlands and the need for any wetlands permits to comply with Section 404 of the Clean Water Act (Hlohowskyj 1990). The Corps determined that no permits for wetland filling or draining activities would be needed for the on-site wetlands because they occur within the boundary of a National Priorities List site and are thus exempt from the requirements of Section 404 of the Clean Water Act (Jewett 1990).

The DOE (McCracken 1991) has also initiated consultations with the U.S. Fish and Wildlife Service regarding the need for mitigation of the on-site wetlands that would be lost as a result of remedial activities at the site. The Fish and Wildlife Service urged DOE to consider wetland creation as a means of mitigating the loss of the on-site wetlands (Brabander 1991). The DOE has initiated surveys of these wetlands to document their size, type, and biotic composition. Upon completion of these surveys and additional consultations with the Fish and Wildlife Service and the Missouri Department of Conservation, DOE will develop a wetlands mitigation plan for the site.

H.4 ALTERNATIVES

Five final alternatives have been identified for addressing contaminated material at the chemical plant area of the Weldon Spring site and vicinity properties, including sediment and soil in the areas of wetland and floodplain involvement. These alternatives, which are described in Chapter 5 of this FS, are:

Alternative 1: No Action;

Alternative 6a: Removal, Chemical Stabilization/Solidification, and Disposal On-Site;

Alternative 7a: Removal, Vitrification, and Disposal On-Site;

Alternative 7b: Removal, Vitrification, and Disposal at the Envirocare Facility near Clive, Utah; and

Alternative 7c: Removal, Vitrification, and Disposal at the Hanford Facility near Richland, Washington

Within the context of these broad alternatives, Alternative 1 is not acceptable for the affected floodplains and wetlands for several reasons. First, implementation of this alternative would not reduce contaminant toxicity, mobility, or volume. Second, the potential for exposure of vegetation, wildlife, and humans would continue. Finally, the contamination could migrate further (e.g., by leaching to groundwater), so that additional exposures could occur over time. The remaining four alternatives are similar to one another in that they each include the excavation and disposal of contaminated sediment and soil from the affected wetlands and the two floodplain areas. These alternatives differ from one another in the proposed treatment and disposal of the contaminated materials. Each of these alternatives is considered to represent a permanent solution to the potential threat to human health and the environment posed by the contaminated sediment and soil at the site and the vicinity properties, and each would provide for long-term protection of human health and the environment associated with related exposures. The removal and subsequent disposal of the contaminated sediment and soil is also consistent with current plans for complete remediation of the Weldon Spring site.

Within the context of this specific floodplain/wetland assessment, there is no practical alternative to removing contaminated material from the affected floodplain and wetland areas. As described for the broad site alternatives, the potential exposures of wetland, floodplain, and some upland species to contaminated media and prey would continue under the no-action alternative. Thus, adverse impacts are associated with leaving the contaminated material in the affected floodplain and wetland areas, and no alternate action to removing this material as proposed would effectively mitigate potential impacts for the long term. The small area of affected floodplain would be graded and recontoured to restore the flood storage volume; mitigation for the wetland areas would be incorporated in the mitigation plan that will be developed by DOE in consultation with other agencies as part of the remedial action process.

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APPENDIX I:

BIOLOGICAL ASSESSMENT FOR THE REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE

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BIOLOGICAL ASSESSMENT FOR THE REMEDIAL ACTION AT THE CHEMICAL PLANT AREA OF THE WELDON SPRING SITE

I.1 INTRODUCTION

The U.S. Department of Energy (DOE) is responsible for cleanup activities at the Weldon Spring site under its Environmental Restoration and Waste Management Program. A major goal of this program is to eliminate potential hazards to human health and the environment. The Weldon Spring site is located in St. Charles County, Missouri, approximately 48 km (30 mi) west of St. Louis (Figure I.1). The site consists of two noncontiguous areas: a chemical plant area and a limestone quarry, which became radioactively and chemically contaminated as a result of processing and disposal activities that occurred from the 1940s through the 1960s. In addition to these areas, a number of off-site locations are chemically and/or radioactively contaminated as a result of past processing activities at the chemical plant. The Weldon Spring site is currently listed on the National Priorities List (NPL) of the U.S. Environmental Protection Agency (EPA).

Explosives were produced at the chemical plant during the 1940s, and uranium and thorium materials were processed during the 1950s and 1960s. Waste slurries generated at the chemical plant area during the latter operational period were piped to four man-made retention ponds, referred to as raffinate pits; various solid wastes (i.e., process residues and decontamination material including soil, rubble, metal debris, and equipment) were disposed of in the quarry between 1942 and 1969. Remedial activities have already begun at the quarry; the most significant activity to be conducted over the next several years is the excavation and transport of contaminated solid material to the chemical plant area for short-term storage pending a decision for disposal of all wastes resulting from remedial action at the Weldon Spring site.

Cleanup of the Weldon Spring site could entail the excavation, treatment, and disposal of approximately 519,000 m^3 (679,000 yd^3) of contaminated sludge, sediment, and soil from a number of on-site and off-site locations. Alternatives being considered for treatment of the more highly contaminated material include chemical stabilization/solidification and vitrification. Alternatives being evaluated for disposal of the contaminated media include the construction of a disposal cell at (1) the chemical plant area of the Weldon Spring site, (2) the Envirocare of Utah, Inc., commercial facility near Clive, Utah, or (3) the 200-West Area at the DOE Hanford facility near Richland, Washington.

Construction and/or backfill activities associated with the different alternatives are estimated to require up to about 1.16 million m^3 (1.52 million yd^3) of clean, uncontaminated borrow (fill) material. Of this amount, DOE might obtain up to 895,000 m^3 (1.17 million yd^3) from a nearby source, potentially from a 61-ha (150-acre) parcel of land located in the Weldon Spring Wildlife Area about 1.9 km (1.2 mi) east of the chemical plant area. The remaining 267,000 m^3 (349,000 yd^3) of borrow material would be obtained from existing commercial sources. In the event that off-site disposal is selected, a dedicated rail siding could be

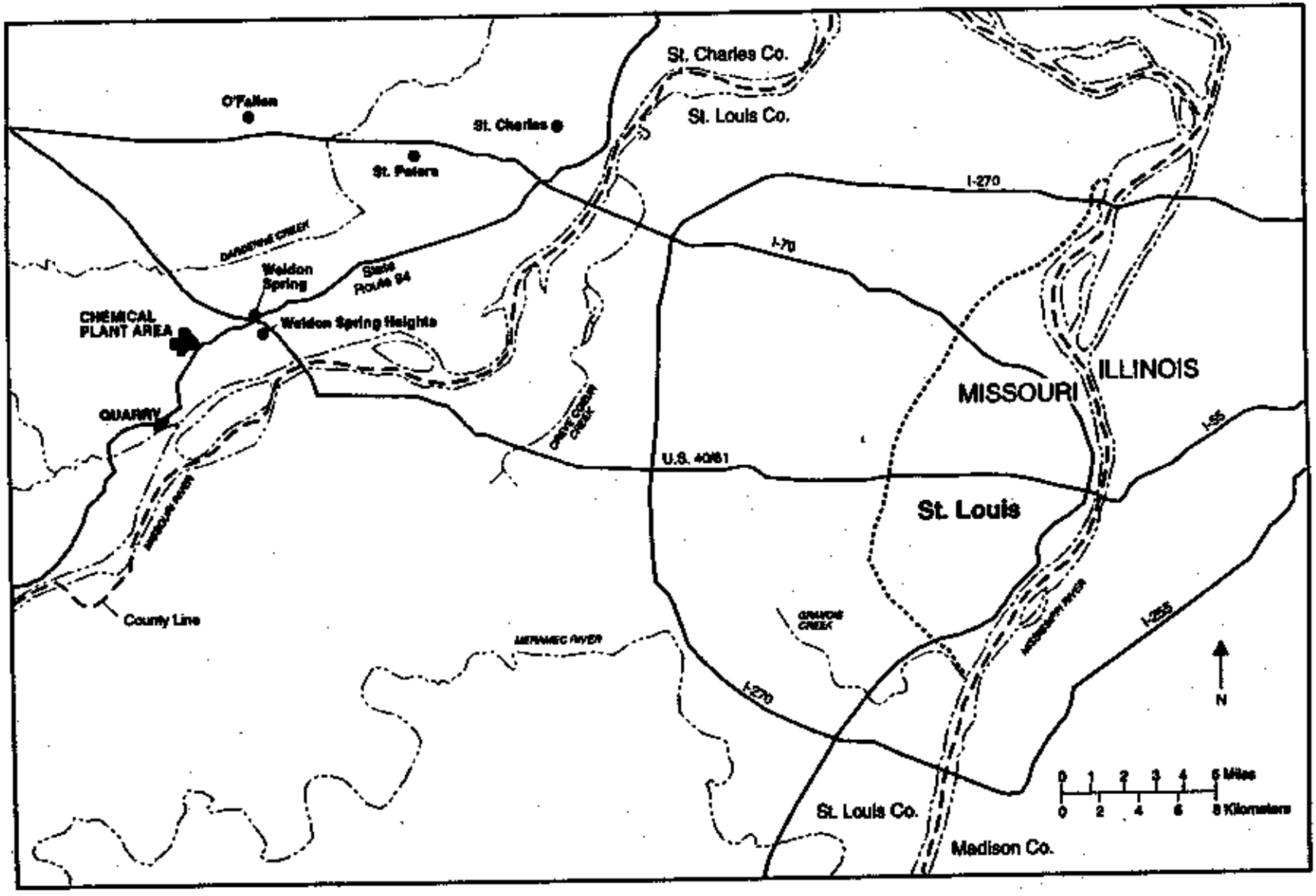

Figure I.1 Location of the Weldon Spring Site

constructed near the town of Wentzville, Missouri, from which treated and untreated containerized material would be shipped by rail to the disposal cell location.

Removal, treatment, and disposal of the contaminated sediment, sludge, and soil at the Weldon Spring site are necessary to eliminate potential hazards to human health and the environment and to complete overall site remediation. Potential environmental impacts of remedial action alternatives for the chemical plant area are evaluated in Chapters 6 and 7 of this feasibility study (FS) for the chemical plant area. This biological assessment evaluates the potential for the remedial action alternatives to adversely affect listed and proposed threatened and endangered species and their designated critical habitats.

I.2 REMEDIAL ACTION ALTERNATIVES

Radioactive and chemical contaminants are present in a number of on-site and off-site areas. The primary radioactive contaminants are uranium, thorium, and radium. Chemical contaminants include metals, inorganic ions, and nitroaromatic compounds. Contaminants of concern for the site are given in Table I.1. Contaminated media include surface water, groundwater, sediment, and soil. The purpose of the planned remedial action at the chemical plant area is to reduce potential hazards to human health and the environment, and to make surplus real property available for other uses to the extent possible. Preliminary estimates of the acreage that would be disturbed and the volumes of contaminated materials associated with the site are given in Table I.2.

Alternative remedial actions were developed by identifying remedial technologies and process options potentially applicable to the contaminated media at the site. The technologies considered included those identified in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA 1990). These technologies and process options were evaluated in accordance with the NCP and EPA guidance (EPA 1988). On the basis of this evaluation, various control technologies were identified as potential components of remedial action alternatives for the site. These technologies were incorporated into seven preliminary alternatives (Section 4.2):

Alternative 1: No Action;

Alternative 2: In-Situ Containment and Limited Disposal;

Alternative 3: In-Situ Chemical Stabilization/Solidification and Limited Disposal;

Alternative 4: In-Situ Vitrification and Limited Disposal;

Alternative 5: Removal, Minimal Treatment, and Disposal;

Alternative 6: Removal, Chemical Stabilization/Solidification, and Disposal; and

Alternative 7: Removal, Vitrification, and Disposal.

TABLE I.1 Contaminants of Concern for the Weldon Spring Site[a]

Radionuclides[b,c]	Metals	Other Inorganic Compounds	Nitroaromatic Compounds	PCBs and PAHs
Actinium-227	Aluminum[d]	Asbestos[b]	DNB	PCBs[b]
Lead-210	Antimony	Fluoride	2,4-DNT[b]	Acenaphthene
Protactinium-231	Arsenic[b]	Nitrate	2,6-DNT[b]	Anthracene
Radium-226	Barium	Nitrite	NB	Benz(a)anthracene[b]
Radium-228	Beryllium[b]		TNB	Benzo(b)fluoranthene[b]
Radon-220	Cadmium[b]		TNT[b]	Benzo(k)fluoranthene[b]
Radon-222	Chromium[b]			Benzo(g,h,i)perylene
Thorium-230	Cobalt			Benzo(a)pyrene[b]
Thorium-232	Copper			Chrysene[b]
Uranium-235	Lead[b]			Fluoranthene
Uranium-238	Lithium			Fluorene
	Manganese			Indeno(1,2,3-cd)pyrene[b]
	Mercury			2-Methylnaphthalene
	Molybdenum			Naphthalene
	Nickel[b]			Phenanthrene
	Selenium			Pyrene
	Silver			
	Thallium			
	Uranium			
	Vanadium			
	Zinc			

[a] Notation: DNB = 1,3-dinitrobenzene; 2,4-DNT = 2,4-dinitrotoluene; 2,6-DNT = 2,6-dinitrotoluene; NB = nitrobenzene; TNB = 1,3,5-trinitrobenzene; TNT = trinitrotoluene, PCBs = polychlorinated biphenyls.

[b] Potential carcinogen.

[c] Exposure to gamma radiation resulting from the presence of these radionuclides was also evaluated.

[d] A contaminant of concern only for the ecological risk assessment.

All of the action alternatives (Alternatives 2 through 7) were further divided into alternative disposal options: disposal in an on-site engineered disposal cell (Alternatives 2a, 3a, 4a, 5a, 6a, and 7a); disposal off-site at the Envirocare facility near Clive, Utah (Alternatives 2b, 3b, 4b, 5b, 6b, and 7b); disposal off-site at the DOE Hanford facility near Richland, Washington (Alternatives 2c, 3c, 4c, 5c, 6c, and 7c); and disposal off-site at a hypothetical nearby facility (Alternatives 2d, 3d, 4d, 5d, 6d, and 7d).

These preliminary alternatives were evaluated for applicability to remediating the Weldon Spring site on the basis of three general criteria: effectiveness, implementability, and cost (Section 4.4). The effectiveness of each alternative was determined by its overall ability to protect human health and the environment in both the short term and long term. The implementability of each alternative was determined by its technical feasibility, resource availability, and administrative feasibility. Relative costs were evaluated at the screening stage by comparing general estimates for each alternative.

TABLE I.2 Estimated Areas and Volumes of Contaminated Media

Medium	Area (acres)	Volume (yd^3)
Sludge		
Raffinate pits	25.8	220,000
Sediment		
On-site	11.5	19,300
Off-site	116.5	100,500
Soil		
On-site	58.4	335,400
Off-site	1.2	3,600
Structural material		
Concrete rubble	4.8	89,200
Steel	3.3	61,900
Debris	0.5	3,700
Asbestos	0.5	9,800
Building 434	0.5	5,000
Process chemicals	1.0	3,960
Vegetation		
From quarry	0.4	6,500
From building demolition	0.1	750
From sitewide areas	3.8	23,400

On the basis of the screening analysis for the preliminary alternatives (Section 4.5 of this FS), five alternatives were retained for detailed evaluation:

Alternative 1: No action;

Alternative 6a: Removal, Chemical Stabilization/Solidification, and Disposal On-Site;

Alternative 7a: Removal, Vitrification, and Disposal On-Site;

Alternative 7b: Removal, Vitrification, and Disposal at the Envirocare Facility near Clive, Utah; and

Alternative 7c: Removal, Vitrification, and Disposal at the Hanford Facility near Richland, Washington.

Under all but the no-action alternative, contaminated materials (Table I.2) would be removed from various source areas, treated as appropriate, and then disposed of in an engineered cell either on-site or off-site.

The alternatives addressed in this biological assessment (and in the FS for remedial action at the chemical plant area) incorporate consideration of the impacts from remedial actions that are currently planned or being developed for most of the contaminated source areas at the Weldon Spring site. This assessment does not, however, address all impacts associated with certain locations whose cleanup is outside the scope of the current decision-making process (i.e., the Southeast Drainage; Femme Osage Slough and vicinity property B9; and Lakes 34, 35, and 36). Those areas are being considered at this stage of the process only with regard to (1) the estimated volume of contaminated media that might be removed from each area under a future action and (2) the disposal cell requirements needed to handle the removed material. They are evaluated for potential impacts to listed and proposed species from the no-action alternative (i.e., in the absence of remedial action).

The Southeast Drainage, an intermittent stream located southeast of the site in the Weldon Spring Wildlife Area (Figure I.2), contains contaminated sediment, soil, and surface water. Contaminants include radionuclides, inorganic ions, and nitroaromatic compounds. Femme Osage Slough is a small portion of Femme Osage Creek that was cut off from its original channel by a levee constructed in 1959 and 1960. The slough, located in the Weldon Spring Wildlife Area south of the Weldon Spring quarry, contains radioactively and chemically contaminated surface water and sediment. Vicinity property B9 is located adjacent to the slough (Figure I.2) and contains contaminated soil. Contaminated surface water, sediment, and soil are also present in portions of Lakes 34, 35, and 36 in the August A. Busch Memorial Wildlife Area.

The Southeast Drainage is being treated as a separate response action, in part because additional characterization is needed for the drainage and also because conditions in the drainage will change as a result of cleanup activities at the chemical plant area. The drainage will be addressed as a separate removal action within the next several years, and environmental documentation will be prepared to support related decisions.

Lakes 34, 35, and 36 will be addressed in conjunction with the Missouri Department of Conservation (MDOC) sedimentation management activities scheduled for these lakes (Dieffenbach 1992). The sedimentation management program addresses the problem of reservoir siltation and also provides for maintenance of the reservoir dams. In this program, a lake targeted for renovation is drained and the accumulated sediments are excavated. The lake is then refilled and restocked with fish. To remediate Lakes 34, 35, 36, DOE will remove contaminated sediment and shoreline soil after the MDOC has drained the lakes. Following removal of the contaminated sediment and soil by DOE, the MDOC will complete sediment removal, refill the lakes, and restore the habitats and biota. A biological assessment may be prepared in the future when the MDOC begins its renovation activities at Lakes 34, 35, and 36. The impacts associated with DOE's removal of the contaminated sediment and soil from these lakes are expected to be identical to the impacts that would be incurred during the scheduled MDOC sediment removal lake renovation activities alone. Because the contaminated areas are only part of the entire area that would be drained and excavated by the MDOC, impacts would be bounded by those associated with the MDOC activities. The overall purpose of these activities is to improve conditions at these lakes.

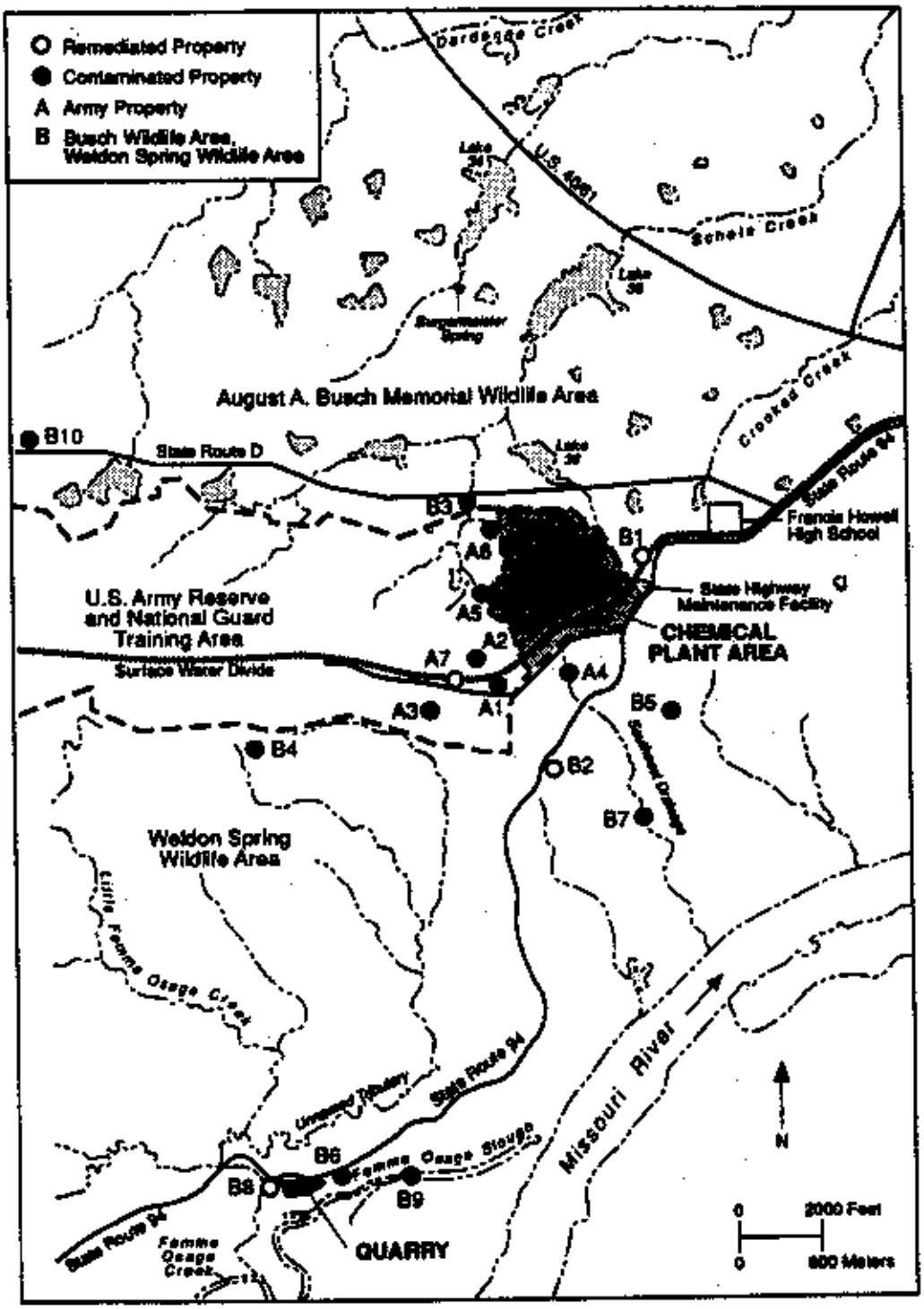

FIGURE L2 Location of Contaminated Vicinity Properties in the Area of the Weldon Spring Site

The Femme Osage Slough and vicinity property B9 (Figure I.2) will be addressed during the follow-on decision-making process for the final cleanup of the quarry (quarry residuals operable unit). A remedial investigation/feasibility study (RI/FS) work plan is being prepared for these areas, and a biological assessment will be included with the planned RI/FS. This document package will incorporate values of the National Environmental Policy Act (NEPA) and will be consistent with the level of analysis for an environmental assessment (EA).

A source of borrow soil is needed to support backfill and construction activities planned for the current stage of site cleanup. A potential location for much of this material (895,000 m^3 [1.17 million yd^3]) has been identified (Figure I.3) and evaluated as the representative borrow area for the analyses in the FS. In the event that the proposed borrow area is selected as the source of clean fill for use at the chemical plant area, an EA would be prepared to address potential impacts from excavation and other activities. Potential impacts from activities at the proposed borrow area to listed, candidate, and Category 2 (C2) species would be evaluated in a biological assessment included in the EA.

I.2.1 Alternative 1: No Action

No action is included as an alternative in the FS to provide a baseline for comparison with the other alternatives. Under this alternative, no further remedial action would be taken at the site. Several interim response actions for which decisions have been finalized are assumed to be in effect as the baseline condition for the site:

- The bulk waste excavated from the quarry is assumed to be in storage on-site in the temporary storage area (TSA).
- The water treatment plants at the quarry and the chemical plant area are assumed to be operational.
- Other than the converted storage building (Building 434), the chemical plant buildings and other structures are assumed to be dismantled and in storage on-site within the material staging area (MSA).

Activities that would continue at the site include environmental monitoring of groundwater, surface water, and air; maintenance of all on-site storage areas, dikes, fences, and remaining buildings; operation of the water treatment plants; and provision of site security.

I.2.2 Alternative 6a: Removal, Chemical Stabilization/Solidification, and Disposal On-Site

Under Alternative 6a, contaminated material from the on-site source areas would be removed, treated (as appropriate), and disposed of in an engineered disposal cell. Contaminated soil, sludge, and sediment would be excavated with conventional earth-moving equipment and dredges. These materials would then be treated by chemical stabilization/solidification to reduce

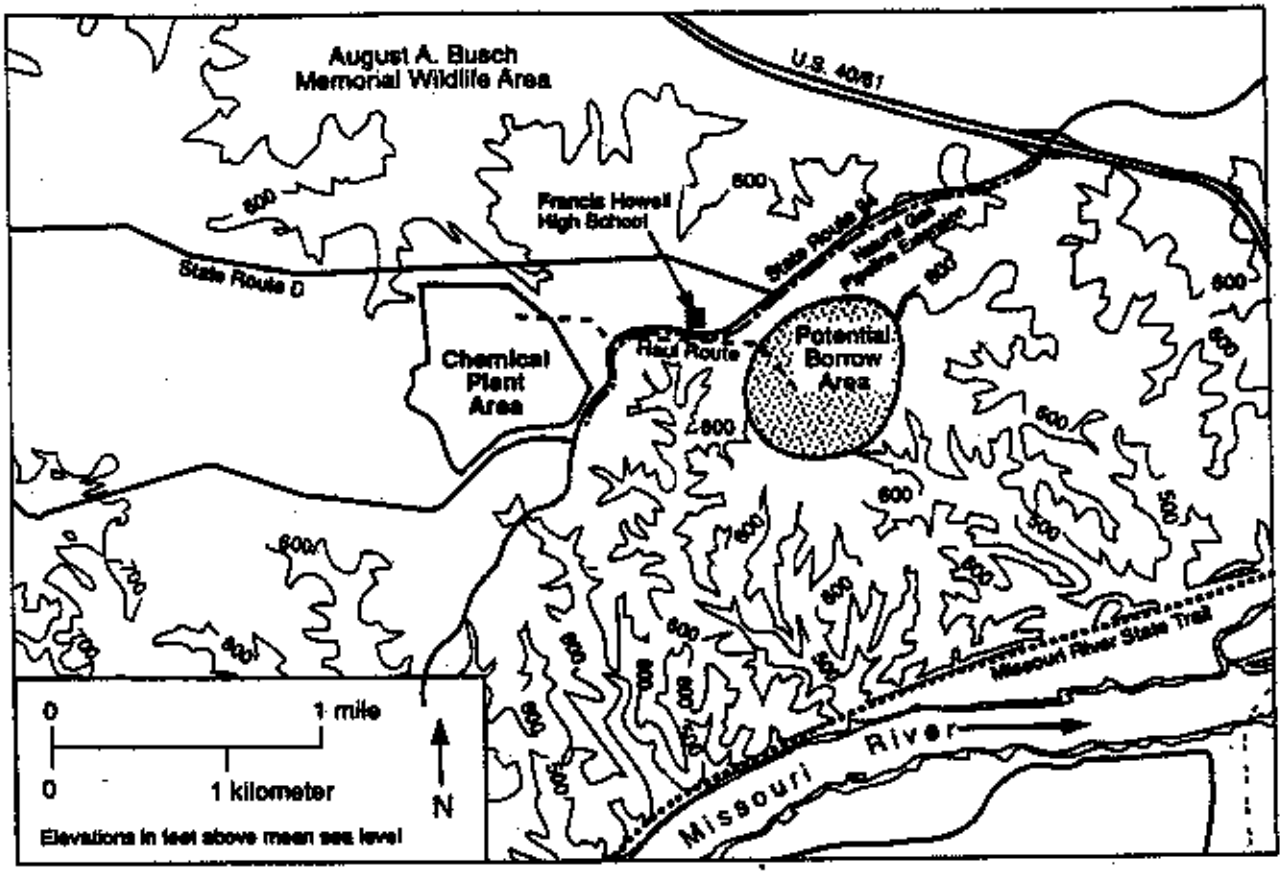

FIGURE I.3 Location of Potential Borrow Area

contaminant mobility, facilitate waste handling, and eliminate free water. Soil, sludge, and sediment in storage at the TSA would also be treated, as appropriate. After treatment, the contaminated material would be placed into an on-site engineered cell. Off-site contaminated soil and sediment would be removed with conventional construction and excavation equipment and transported to the chemical plant area in covered trucks for similar treatment and/or disposal.

Chemical stabilization/solidification of the contaminated media would be accomplished by mixing the contaminated material with a reagent consisting of a blend of cement and fly ash. This treatment would occur in an engineered treatment facility built on-site that would require an area of approximately 0.40 ha (1.0 acre). A volume reduction facility, occupying an area of approximately 0.084 ha (0.21 acres), would also be built on-site to reduce the volume of structural material (such as metal, concrete, and glass), rock, and containerized decontamination material, which would also facilitate waste handling and disposal. Following chemical treatment or volume reduction, the contaminated material would be transported by truck to an on-site engineered disposal cell (Figure I.4).

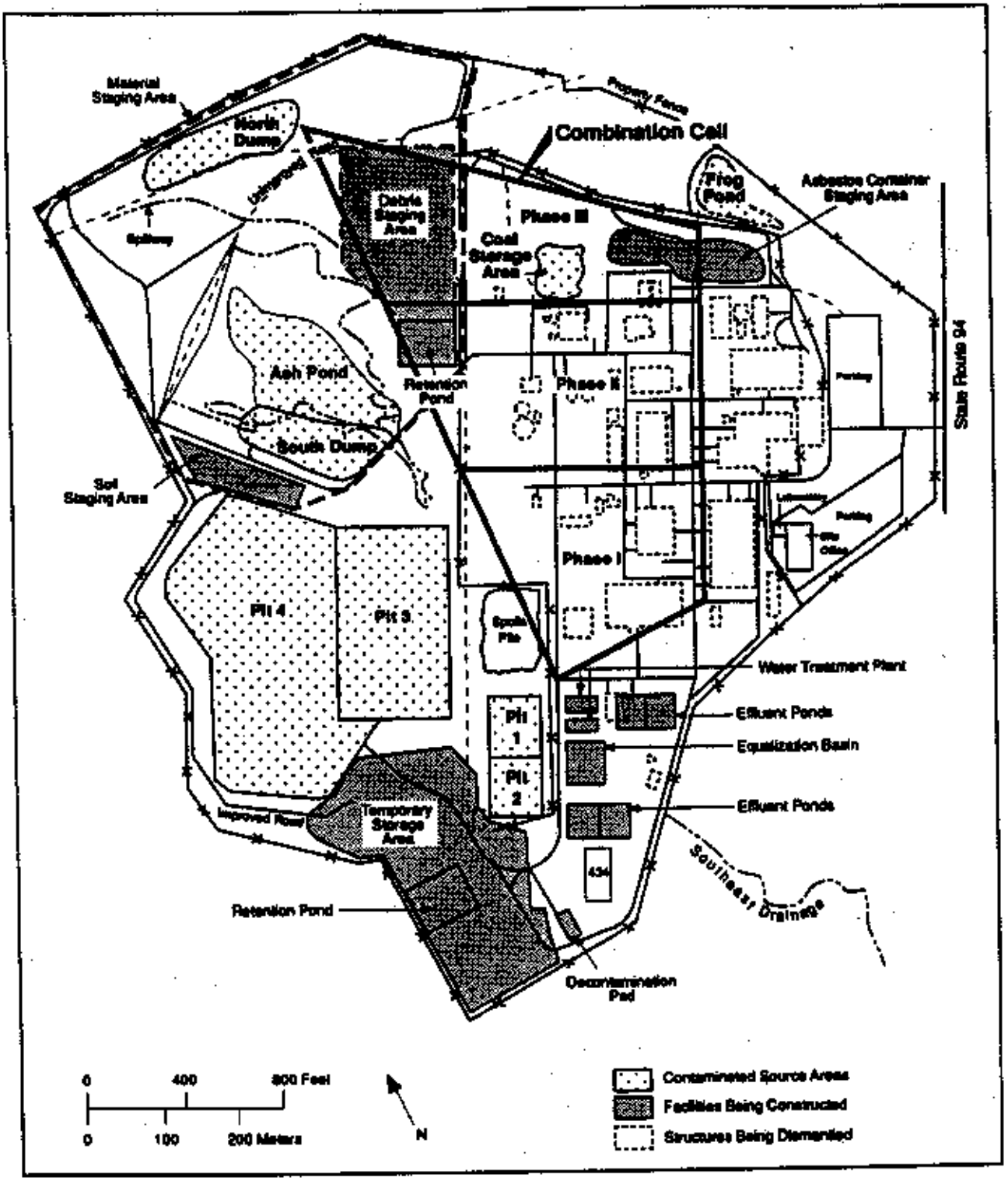

FIGURE I.4 Conceptual Layout of the Combination Disposal Cell for Alternative 6a

The disposal cell would include a bottom composite liner (synthetic membrane and compacted clay), a leachate collection and removal system, and a multilayer cover system including an infiltration/radon attenuation barrier (Section 5.2.3). The design would incorporate features used in disposal cells for radium-contaminated uranium mill tailings (such as the DOE Uranium Mill Tailings Remedial Action [UMTRA] Program disposal cell design) and solid and hazardous waste (such as the Resource Conservation and Recovery Act [RCRA] disposal cell design). This type of disposal cell is referred to as a combination cell. The cell would be located on-site and would occupy an area of about 17 ha (42 acres).

Good engineering practices and appropriate mitigative measures would be used during all excavation and construction activities to prevent or minimize potential erosion, dust emissions, and contaminant releases. Following completion of remedial action activities and closure of the treatment and storage facilities and disposal cell, the site would be graded and vegetated. Clean borrow and topsoil would be used to reclaim excavated areas (including the raffinate pits). The site would be graded to match undisturbed areas, prevent ponding, minimize erosion, and provide a transition into natural drainages in the area. Except for the disposal cell, which would be planted with grasses, the site would be seeded with hardy native vegetation, including shrubs and trees.

I.2.3 Alternative 7a: Removal, Vitrification, and Disposal On-Site

Under Alternative 7a, contaminated sludge, soil, and sediment would be removed from the on-site and off-site source areas in the same manner as identified for Alternative 6a. In contrast to Alternative 6a, the contaminated material under Alternative 7a would be treated by vitrification rather than chemical stabilization. Under the vitrification option, the highly contaminated soil, sludge, and sediment would be placed in an enclosed vessel and melted, then quenched with water to produce a small (<0.64-cm [<0.25-in.] diameter) fritted glass product. Organic contaminants and some inorganic contaminants would be destroyed by the high vitrification temperatures, whereas the radioactive and other inorganic contaminants would be trapped in the glass-like product. The fate of contaminants during vitrification is shown in Table I.3. The lightly contaminated soil and sediment and the structural material would not be vitrified.

Two treatment facilities would be built on-site: a volume reduction facility identical to that described for Alternative 6a and a sludge processing facility (0.40 ha [1.0 acre]) with dewatering and vitrification systems. Contaminated sludge and sediment would be dewatered prior to vitrification, and the water removed during the dewatering process would be treated in the on-site water treatment plant. The dewatered material would then be fed to the vitrification system for treatment. An off-gas treatment system (e.g., primary and aerosol scrubbers) would be used to remove entrained dust, submicron aerosols, and noncombustible gases created during vitrification of contaminated soil, sludge, and sediment. As a final filtration step, all off gas would be passed through high-efficiency-particulate air (HEPA) filters.

TABLE I.3 Fate of Contaminants during Vitrification

Contaminant	Unit	Annual Feed Rate[a]	Fate of Contaminants as Percent of Feed: Encased in Glass (%)	Scrubber Residuals (%)	Released to Atmosphere[b] (%)
Metals	tons				
Arsenic		28.3	77.57	22.43	5.9×10^{-6}
Cadmium		1.4	75.05	24.95	6.6×10^{-6}
Chromium		2.4	99.77	0.23	1.2×10^{-8}
Copper		18.7	99.77	0.23	1.2×10^{-8}
Lead		17.3	93.12	6.88	1.8×10^{-6}
Mercury		0.3	0	40.0	60.0
Nickel		21.4	99.77	0.23	1.2×10^{-8}
Selenium		2.3	0.06	99.94	2.6×10^{-5}
Vanadium		196	99.77	0.23	1.2×10^{-8}
Zinc		16.9	98.18	1.82	9.2×10^{-6}
Inorganic anions	tons				
Chloride[c]		0.3	0.10	94.90	4.99
Fluoride[d]		2.3	99.77	0.23	0.0023
Nitrates[e]		141	0	50.0	50.0
Nitrites[e]		1.4	0	50.0	50.0
Sulfate[f]		262	74.07	23.33	2.59
Nitroaromatic compounds[g]	tons				
2,4-DNT		0.2	<0.10	<0.10	0.0001
2,6-DNT		0.2	<0.10	<0.10	0.0001
2,4,6-TNT		5.9	<0.10	<0.10	0.0001
Other	tons				
Organic nitro groups		1.3	0	50.0	50.0
Thermal NO_x[h]		274	0	95.30	4.7
Total nonvolatile solids		45,600	99.77	0.23	1.2×10^{-8}
Radionuclides[i]	Ci				
Actinium-227		16.2	99.77	0.23	1.2×10^{-8}
Lead-210		58.5	93.12	6.88	1.8×10^{-6}
Polonium-210		55.1	99.77	0.23	1.2×10^{-8}
Protactinium-231		20.4	99.77	0.23	1.2×10^{-8}
Radium-226		23.6	99.77	0.23	1.2×10^{-8}
Radium-228		5.7	99.77	0.23	1.2×10^{-8}
Thorium-230		458	99.77	0.23	1.2×10^{-8}
Thorium-232		5.3	99.77	0.23	1.2×10^{-8}
Uranium-235		1.28	99.77	0.23	1.2×10^{-8}
Uranium-238		27.9	99.77	0.23	1.2×10^{-8}

See next page for footnotes.

TABLE I.3 (Cont.)

[a] Based on an annualized daily average feed of 125 tons per day.

[b] Estimated from the expected operating conditions for the vitrification and off-gas treatment systems.

[c] Chloride is released as hydrogen chloride (HCl).

[d] Fluorides are not expected to volatilize and are therefore assumed to be released in the mineral form, e.g., apatite.

[e] Released as nitrogen dioxide (NO_2).

[f] Sulfate is released as sulfur dioxide (SO_2).

[g] Fate of nitroaromatic compounds is based on an assumed destruction and removal efficiency of 99.9999%. Partitioning between glass and scrubber sludge is based on an assumed treatment system efficiency of 99.9% and a destruction efficiency of 99.9%.

[h] Thermal nitrogen oxides (NO_x) are not present in the feed but are created from nitrogen and oxygen in the air; except for annual feed rates, quantities are reported as percentages of the NO_x-forming components of the feed (nitrates, nitrites, and organic nitro groups).

[i] The activities of actinium-227, protactinium-231, and uranium-235 are derived from the radiological source term analysis for the raffinate pit sludge (Table 2.3 of the baseline assessment [DOE 1992a]). Radon-222 is not included in this table because it was assumed that 100% of the radon is released to the atmosphere. It is estimated that about 100 Ci of radon-222 would be released from the off-gas treatment system over a 4-year period.

Source: MK-Ferguson Company and Jacobs Engineering Group (1992b).

Two on-site disposal cell designs could be used for Alternative 7a (Figure I.5). Because the vitrified waste would be chemically inert and the vitrified product very resistant to leaching, this material could be disposed of in a cell with a single foundation liner (the vitrification cell). The untreated waste (i.e., soil, sediment, and structural material with relatively low contaminant concentrations) could be stored in an adjacent cell (the combination cell) with a design similar to that identified for Alternative 6a, except smaller. The total area covered by both cells would be about 17 ha (42 acres), 4.9 ha (12 acres) for the vitrification cell and 12 ha (30 acres) for the combination cell.

Good engineering practices and appropriate mitigative measures would be used during all excavation and construction activities to prevent or minimize potential erosion, dust emissions, and contaminant releases. Following completion of remedial action activities and closure of the treatment and storage facilities and disposal cell, the site would be renovated in the same manner as described for Alternative 6a.

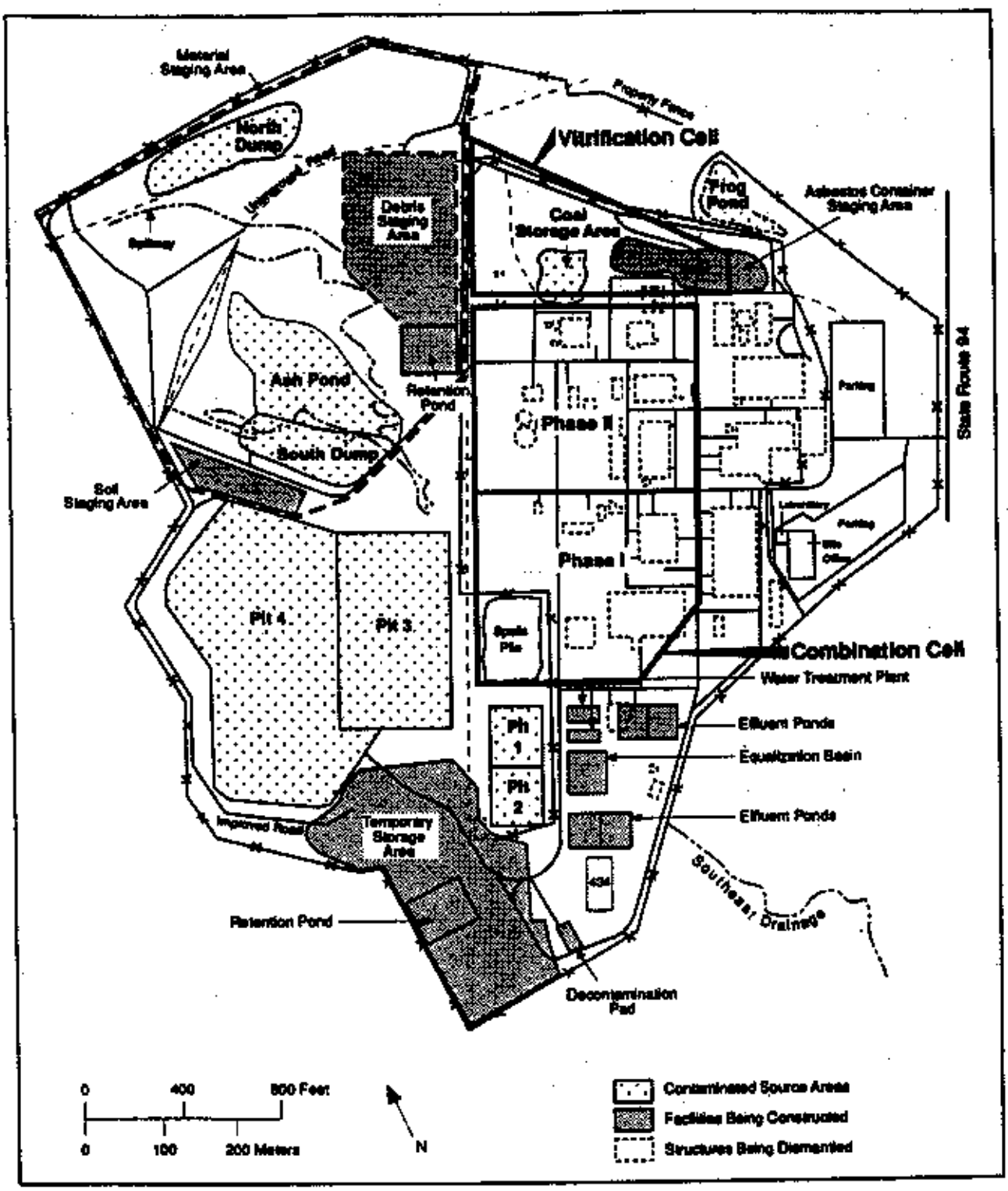

FIGURE I.5 Conceptual Layout of the Vitrification Cell and Combination Cell for Alternative 7a

I.2.4 Alternative 7b: Removal, Vitrification, and Disposal at the Envirocare Facility

Under Alternative 7b, contaminated material would be removed from source areas in the same manner as identified for Alternative 6a. The contaminated material would be treated in same manner as described for Alternative 7a and would also require a volume reduction facility and a sludge processing facility with dewatering and vitrification processes. Material not vitrified would be delivered to a 4-ha (10-acre) staging and loading area located on-site. At this area, the untreated material would be placed into specially designed containers for off-site transport. These containers would be similar to those used for DOE's UMTRA program; the containers fit on railroad flatcars specially designed for their use.

Both the vitrification and volume reduction facilities would be equipped to directly load containers. After filling, the containers would be covered, sealed, and decontaminated. The filled containers would be placed onto low-bed trucks (one container per truck) equipped with brackets to secure the containers. The containers would then be transported to a 4.5-ha (11-acre) rail siding near Wentzville, Missouri, where they would be transferred to the railroad flatcars for transport to the Envirocare facility near Clive, Utah. The Envirocare facility is currently accessible by a rail siding. At this siding, the containers would be transferred to trucks and then transported to a disposal cell with a design assumed to be similar to that identified for Alternative 7a (Sections 5.3.3 and 5.4.3).

Good engineering practices and appropriate mitigative measures would be used during all excavation and construction activities to prevent or minimize potential erosion, dust emissions, and contaminant releases. Following completion of remedial action activities and closure of the treatment facilities, the site would be renovated in a manner similar to that identified for Alternative 6a. Following removal of contaminated source areas, excavated areas would be backfilled with clean borrow and topsoil, and the site would be graded to incorporate broad, gently sloping drainage swales into natural drainage paths. The site would then be seeded with hardy, native vegetation.

I.2.5 Alternative 7c: Removal, Vitrification, and Disposal at the Hanford Facility

The removal and treatment of contaminated material under Alternative 7c is identical to that identified for Alternative 7b. Under Alternative 7c, contaminated material from the Weldon Spring site would be placed in an engineered disposal cell located at the 200-West Area of the DOE Hanford facility near Richland, Washington. Packaging and transport of the treated and untreated material from the Weldon Spring site onto railcars at the Wentzville siding would be identical to that identified for Alternative 7b. The contaminated material would then be transported to the Hanford facility. The Hanford facility is currently accessible by a rail siding, and the waste containers would be transferred at the site to trucks and then transported to a disposal cell with a design similar to that identified for Alternative 7a. The disposal cell is assumed to require approximately 17 ha (42 acres), and cell design considerations and support facilities are assumed to be similar to those identified for Alternative 7a (Sections 5.3.3 and 5.5.3).

I.3 AFFECTED ENVIRONMENT

I.3.1 Weldon Spring Site

The Weldon Spring site is located on the drainage divide of the Missouri and Mississippi rivers, about 2.4 km (1.5 mi) northwest of the Missouri River. The 88-ha (217-acre) chemical plant area contains about 40 buildings and structures, four man-made retention ponds (raffinate pits), two man-made ponds (Ash Pond and Frog Pond), and two former dump areas (Figure I.6). These structures and areas are radioactively and/or chemically contaminated. Most of the area surrounding the chemical plant area is part of the MDOC Busch Wildlife Complex (6,835 ha [16,890 acres]). This complex consists of three wildlife areas: the August A. Busch Memorial Wildlife Area (2,829 ha [6,987 acres]) to the north of the chemical plant area, the Weldon Spring Wildlife Area (2,978 ha [7,356 acres]) to the south and east, and Howell Island Wildlife Area (1,031 ha [2,547 acres]) in the Missouri River to the southeast of the chemical plant (MDOC 1989).

Much of the chemical plant area (approximately 66 ha [162 acres]) is developed (i.e., industrialized) and contains grassland and old-field habitats that are subjected to periodic mowing. The remainder of the area (about 22 ha [55 acres] in the northwestern portion of the site) consists of relatively undisturbed old-field and upland forest habitat. In addition to a resident fauna, the chemical plant area (and particularly the northwestern portion of the site) is probably utilized by a number of species that move freely between on-site and off-site locations.

Aquatic habitats at the chemical plant area cover about 15 ha (38 acres) and include the raffinate pits, Ash Pond, Frog Pond, and the drainages from these ponds; all contain surface water, sediment, and soil that are radioactively and chemically contaminated. The on-site surface waters attract waterfowl and shorebirds, and large numbers of waterfowl have at times been observed using some of these habitats. Waterfowl that have been observed at the raffinate pits and Ash Pond include wood duck, mallard, blue-winged teal, scaup, and Canada goose (Hlohowskyj 1990).

The nearby wildlife areas (Figure I.2) contain a variety of habitats, including grasslands, wetlands, forests, and cultivated fields of row crops and grasses; forest habitats are the most abundant and widespread. Existing aquatic habitats include over 30 lakes and 60 ponds. A total of 29 mammal species, 47 reptile species, 25 amphibian species, and 105 fish species have been reported from St. Charles County (Dickneite 1988), and many of these species occur at the wildlife areas. At least 277 avian species having been reported from the wildlife areas (MDOC 1991), and more than 100 species breed in the area.

I.3.2 Wentzville Rail Siding

The proposed rail siding that could be constructed under Alternatives 7b and 7c would be located along the existing rail lines in the town of Wentzville, Missouri. Wentzville is

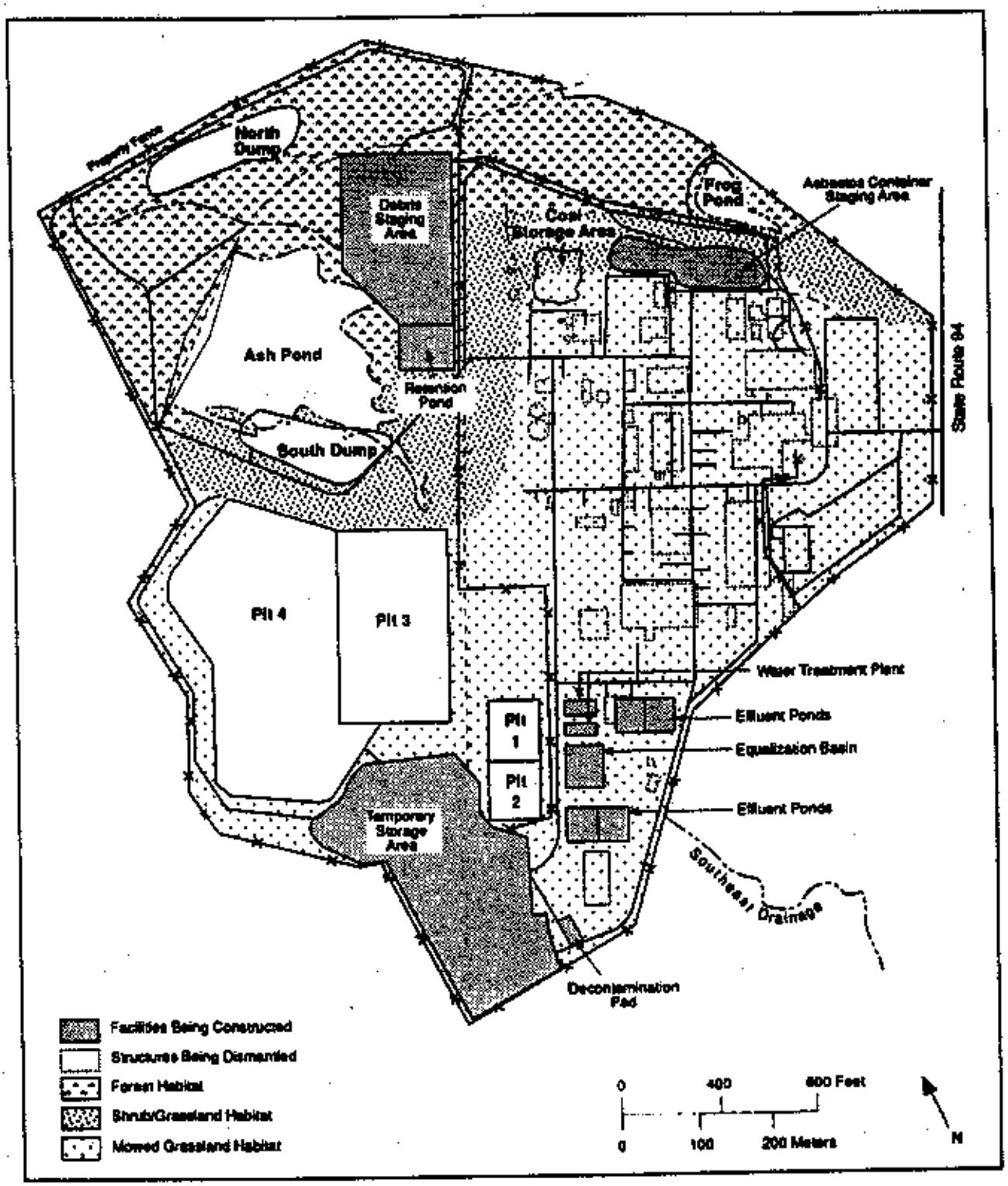

FIGURE I.6 Terrestrial and Aquatic Habitats at the Weldon Spring Site

approximately 24 km (15 mi) northwest of the Weldon Spring site. No wetlands (U.S. Fish and Wildlife Service 1989) or floodplains (Federal Insurance Administration 1978) are located along the existing rail lines, and no state-listed species or sensitive communities are known to occur in the Wentzville area (Dickneite 1991). The area currently contains several rail sidings and is served by both the Union Pacific and Burlington Northern railroads (Section 4.2.2.2).

I.3.3 Envirocare Site

The Envirocare site near Clive, Utah, contains a commercial disposal facility licensed by the state of Utah for naturally occurring radioactive material (NORM), as well as mixed NORM and chemically hazardous waste. The site is located on the eastern edge of the Great Salt Lake Desert in Tooele County, Utah, approximately 129 km (81 mi) west of Salt Lake City (Figure I.7). The Envirocare site occupies approximately 220 ha (540 acres) in a county set-aside area zoned for radioactive waste disposal, and is located approximately 0.62 km (1 mi) south of a rail switch point identified as Clive (Figure I.8). Approximately 40 ha (100 acres) adjacent to the site is the disposal location for uranium mill tailings removed from Salt Lake City as part of the UMTRA program (Envirocare of Utah 1991). Much of the land surrounding the Envirocare site is public domain administered by the U.S. Bureau of Land Management (DOE 1984).

The Envirocare site is situated in an arid desert area rated by the Bureau of Land Management as being poor for grazing or forage production. Vegetation at the site is a homogeneous, semidesert low shrubland, composed primarily of shadscale (Figure I.9). This shrubland is part of the northern desert shrub biome of the cold desert formation and has been described as a saltbrush (shadscale)-greasewood shrub complex (DOE 1984). Plant communities identified in the area are shadscale-gray molly, black greasewood-Gardner saltbrush, and a shadscale-gray molly/black greasewood transitional community (Figure I.8); all three communities are low in species diversity. The vegetation forms an important ground cover that provides habitat for wildlife.

Animal species reported from the area — all of which may breed or nest there — include black-tailed jackrabbit, deer mouse, grasshopper mouse, horned lark, and desert horned lizard (Envirocare of Utah 1991). No wetlands or other aquatic habitats are present at or in the vicinity of the Envirocare facility. The nearest stream channel ends approximately 3 km (1.9 mi) east of the site, and the nearest body of permanent surface water is Big Spring, about 45 km (28 mi) east of the facility.

I.3.4 Hanford Site

The Hanford site (comprising approximately 1,450 km^2 [560 mi^2]) is located within the Pasco Basin of the Columbia River, a semiarid region of desert in southeastern Washington State. Because the site includes widely spaced clusters of industrial buildings, much of this desert is undeveloped. The developed areas account for only about 6% of the total land area of the site. No livestock grazing or tillage has occurred there since the early 1940s.

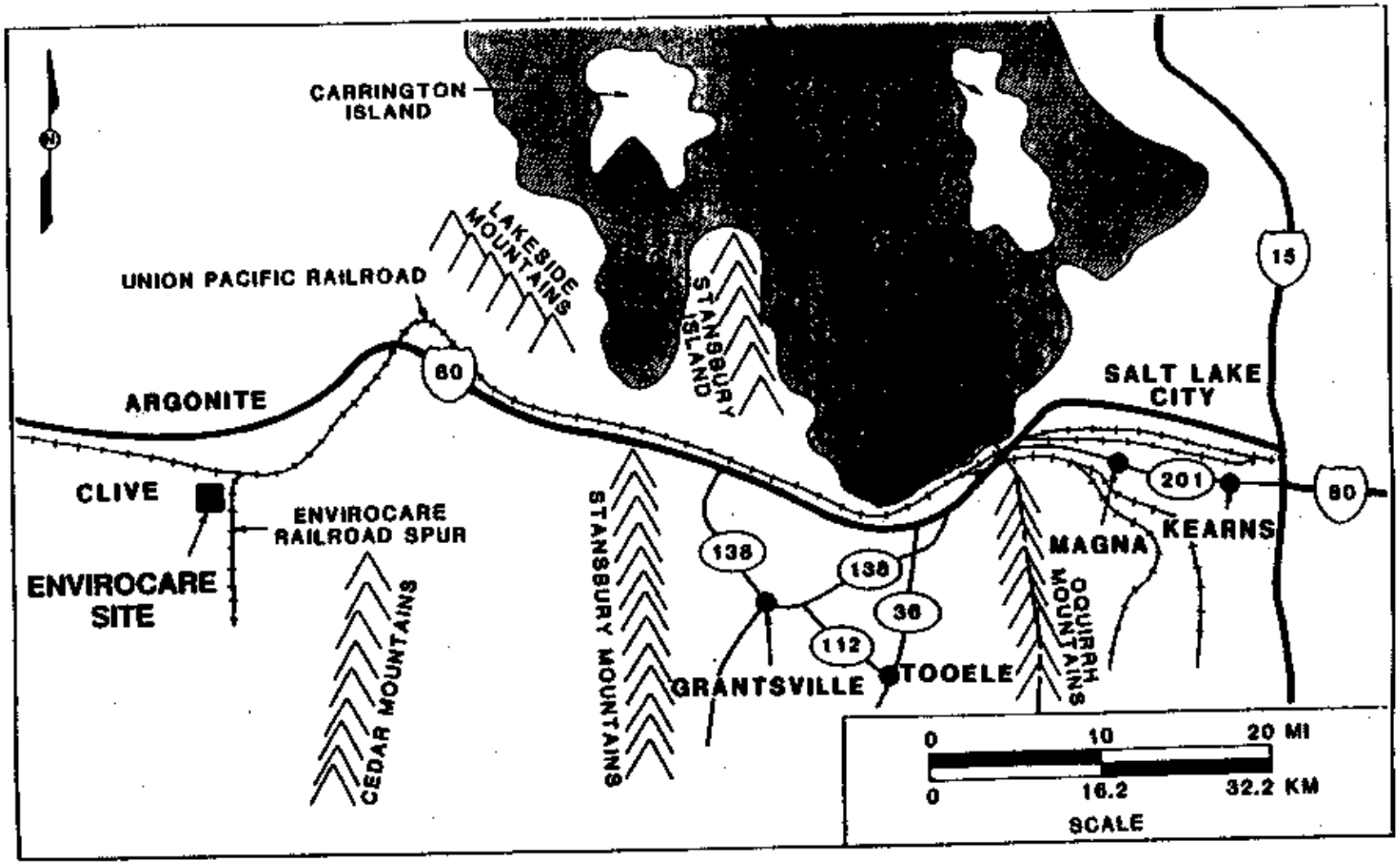

FIGURE I.7 Location of the Envirocare Site near Clive, Utah (Source: Modified from DOE 1992c, Figure 2-1)

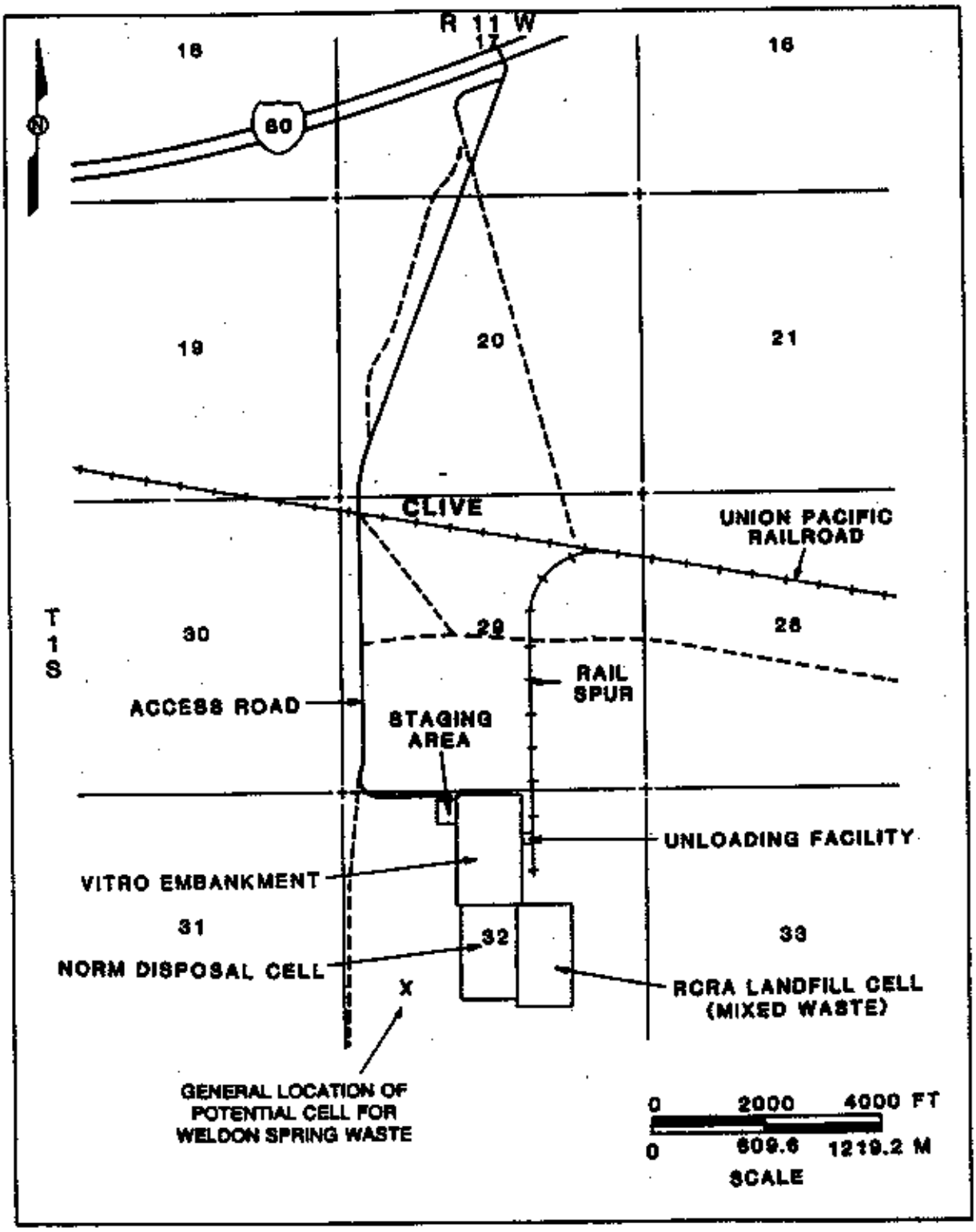

FIGURE L8 Operational Areas within the Envirocare Site (Source: Modified from DOE 1992c, Figure 2-2)

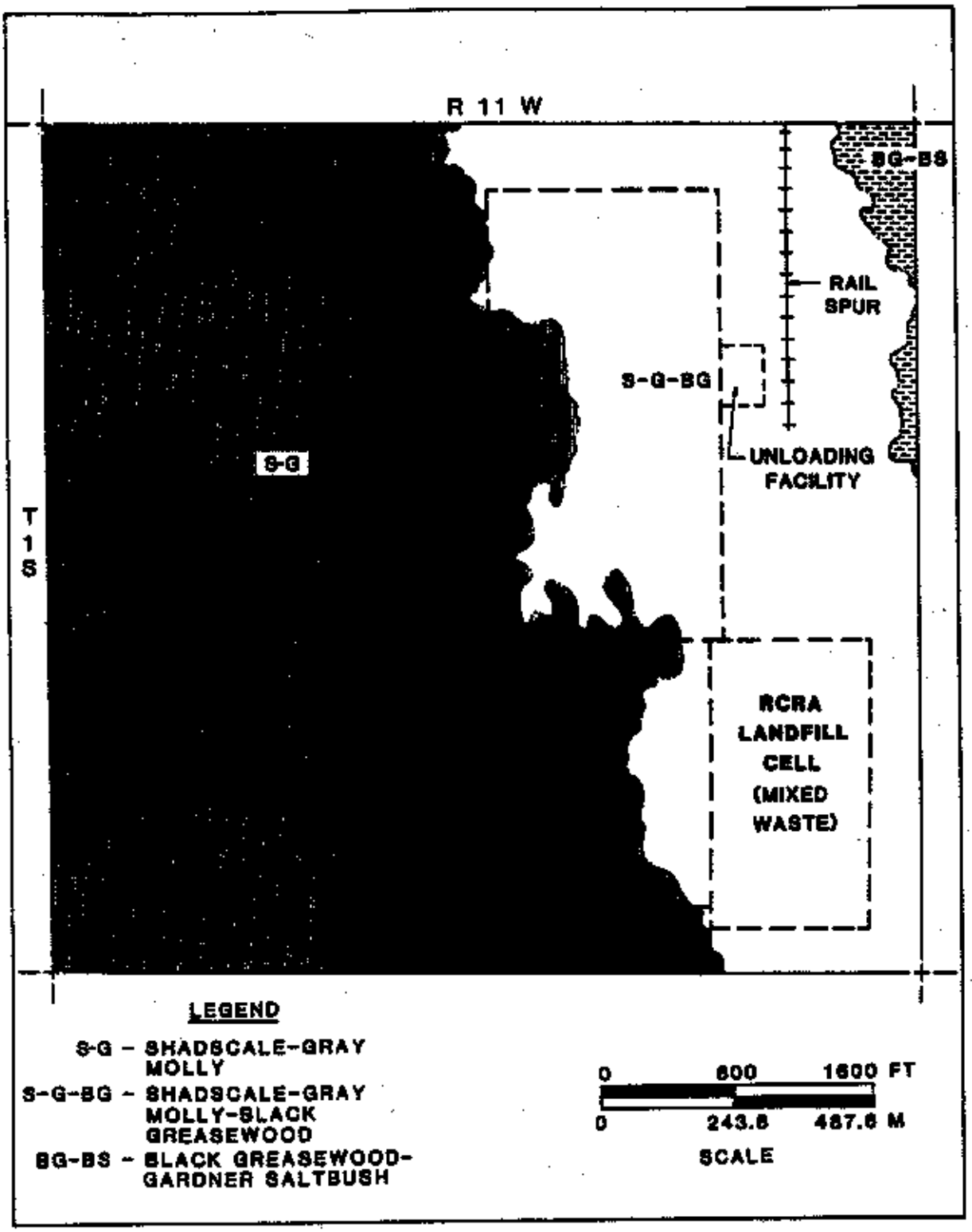

FIGURE I.9 Vegetation Map of the Envirocare Site (Source: Modified from DOE 1992c, Figure 2-4)

The Columbia River flows through the northern part of the site and forms the site's eastern boundary (Figure I.10). This section of the Columbia River, referred to as the Hanford Reach, is the largest free-flowing portion of the river; however, the daily and seasonal water fluctuations have been altered by dams upstream and downstream of the site (Pacific Northwest Laboratory 1991). The major portion of the site provides a buffer around the smaller areas used for production of nuclear materials, research, and waste management and disposal. This buffer is composed of several national and state wildlife refuges, including the Saddle Mountain National Wildlife Refuge and the state Wahluke Wildlife Refuge Area to the north, the Arid Lands Ecology Reserve to the west and southwest, the state Rattlesnake Slope Wildlife Refuge Area to the southwest, and the McNary National Wildlife Refuge to the east along the Columbia River (Figure I.11). The location evaluated for the potential off-site disposal cell is the 200-West Area of the 200-Area plateau. This area contains the Hanford waste management facilities and the Plutonium Processing Facility (DOE 1991).

The Hanford site is characterized by shrub-steppe desert that supports numerous plant and animal species adapted to a semiarid environment (Pacific Northwest Laboratory 1991). The site supports eight major vegetation types (Figure I.12). The potential disposal cell would be located in the 200-West Area, which is dominated by the sagebrush/cheatgrass or sagebrush/Sandberg's bluegrass community type. More than 100 plant species occur in the 200-Area plateau, and mosses and lichens are common on the soil surface. Because of past grazing, cheatgrass accounts for 50% of the plant cover in the 200-Area plateau (Pacific Northwest Laboratory 1991).

The Hanford site contains no marshes, estuaries, or designated wetlands. The banks of the Columbia River (and its islands) afford some semiaquatic habitat. Of the three ponds on-site, only one (West Lake, near the 200-East Area) is natural. The remainder are semipermanent artificial ponds created for the disposal of cooling water. These ponds are dominated by cattails, reeds, and trees such as willow, cottonwood, and Russian olive.

Several passerine bird species — including the sage sparrow, sage thrasher, and loggerhead shrike — rely on sagebrush or bitterbrush for nesting habitat, the vegetation type typical of the 200-West Area. Bitterbrush is also an important browse for mule deer. Mature sagebrush and bitterbrush burn readily, creating habitat devoid of shrubs that is suitable for ground-nesting birds such as the long-billed curlew, horned lark, Western meadowlark, and burrowing owls. More than 125 species of birds are found throughout the site.

Approximately 30 species of mammals and more than 300 species of terrestrial and aquatic insects have been documented on the Hanford site (Pacific Northwest Laboratory 1991). Abundant mammal species include the Great Basin pocket mouse, deer mouse, Townsend's ground squirrel, Northern pocket gopher, Western harvest mouse, sagebrush vole, and Merriam's shrew. The principal predator is the coyote. Grasshoppers and darkling beetles are the most conspicuous groups of insects and form important components of the prey base of birds and mammals. Sixteen species of amphibians and reptiles have been observed at the site. The side-blotched lizard is the most common and is found throughout the site.

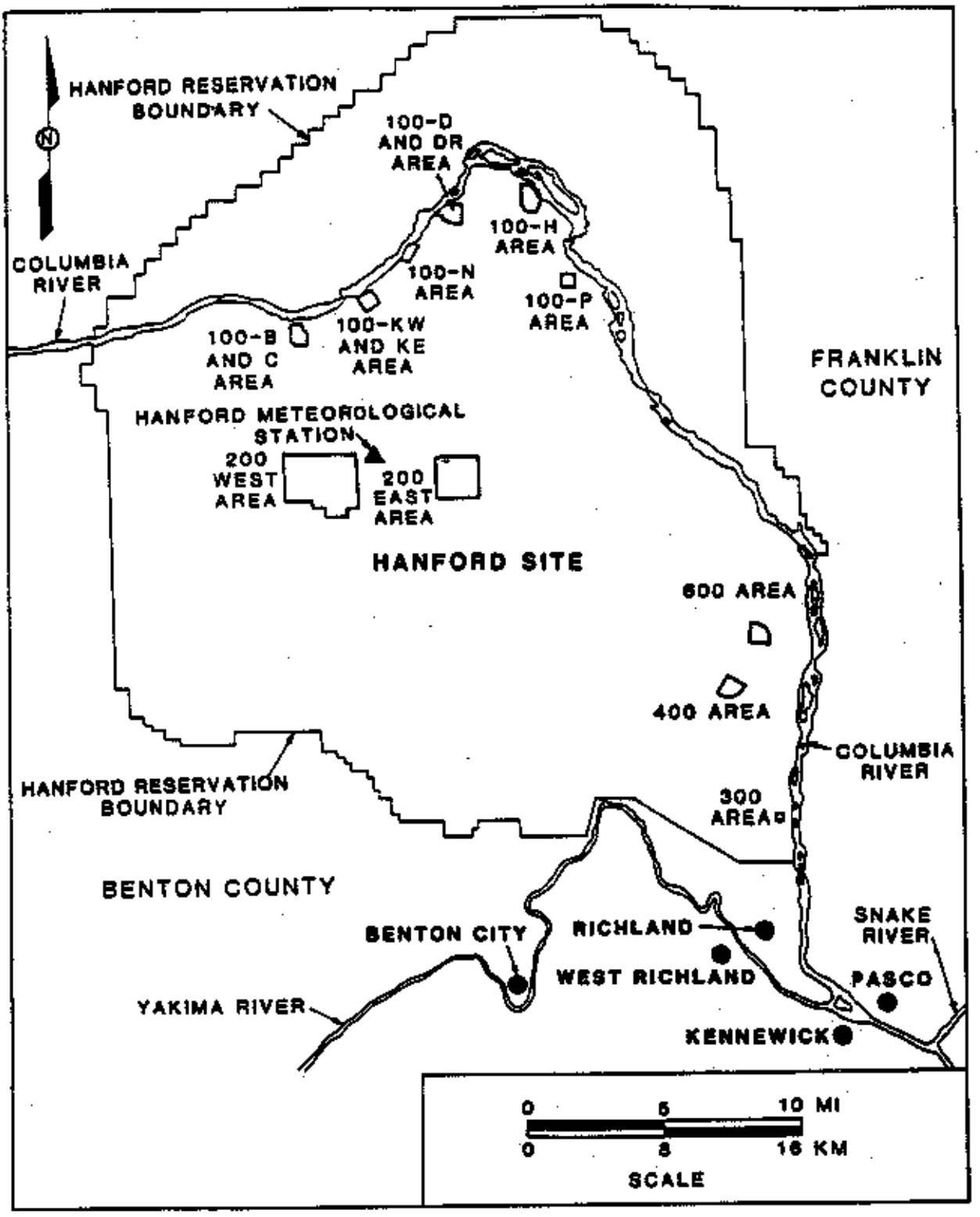

FIGURE I.10 DOE Operational Areas within the Hanford Site (Source: Modified from DOE 1992c, Figure 3-2)

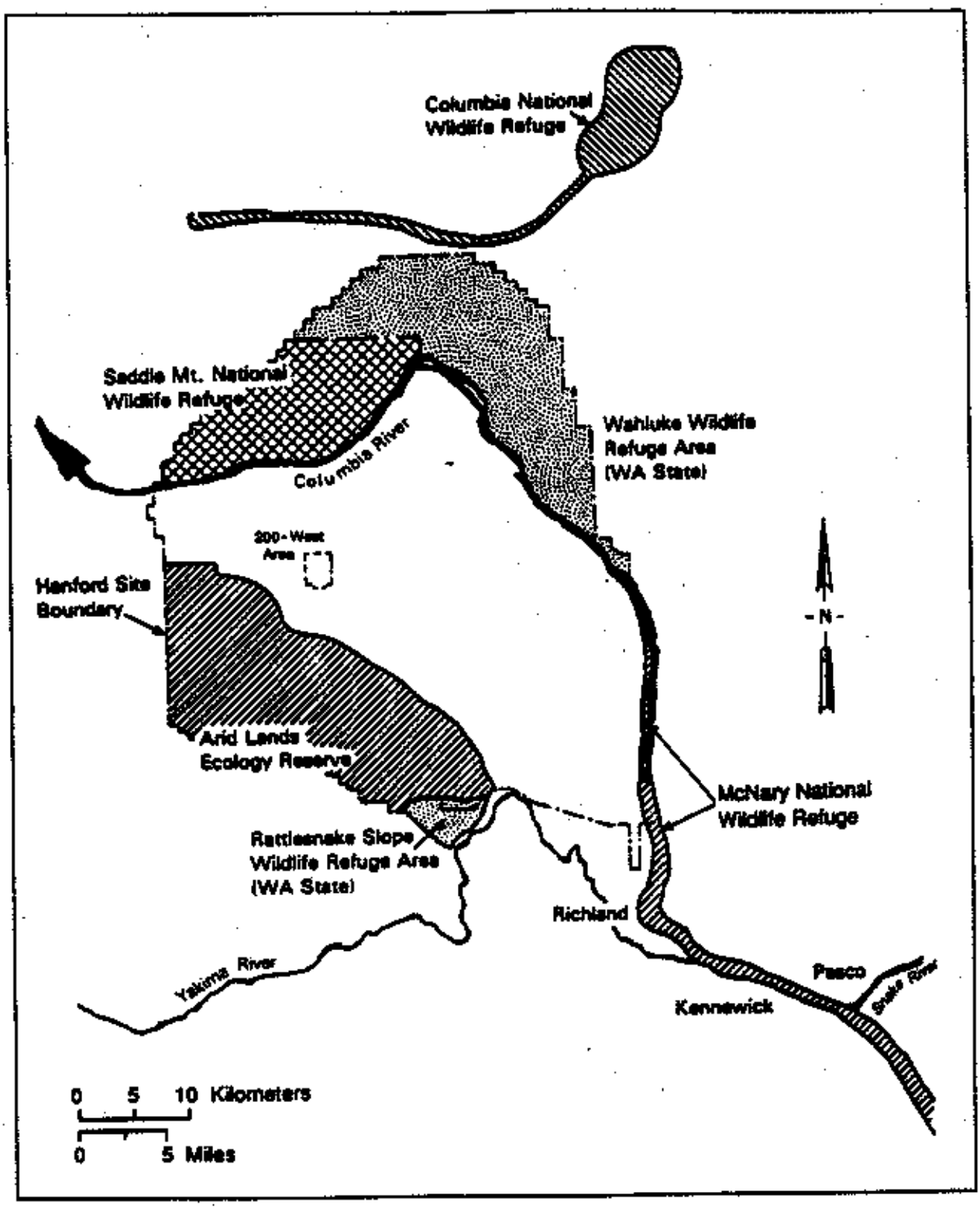

FIGURE I.11 National and State Wildlife Refuges in the Vicinity of the Hanford Site (Source: Modified from Pacific Northwest Laboratory 1991, Figure 5.7)

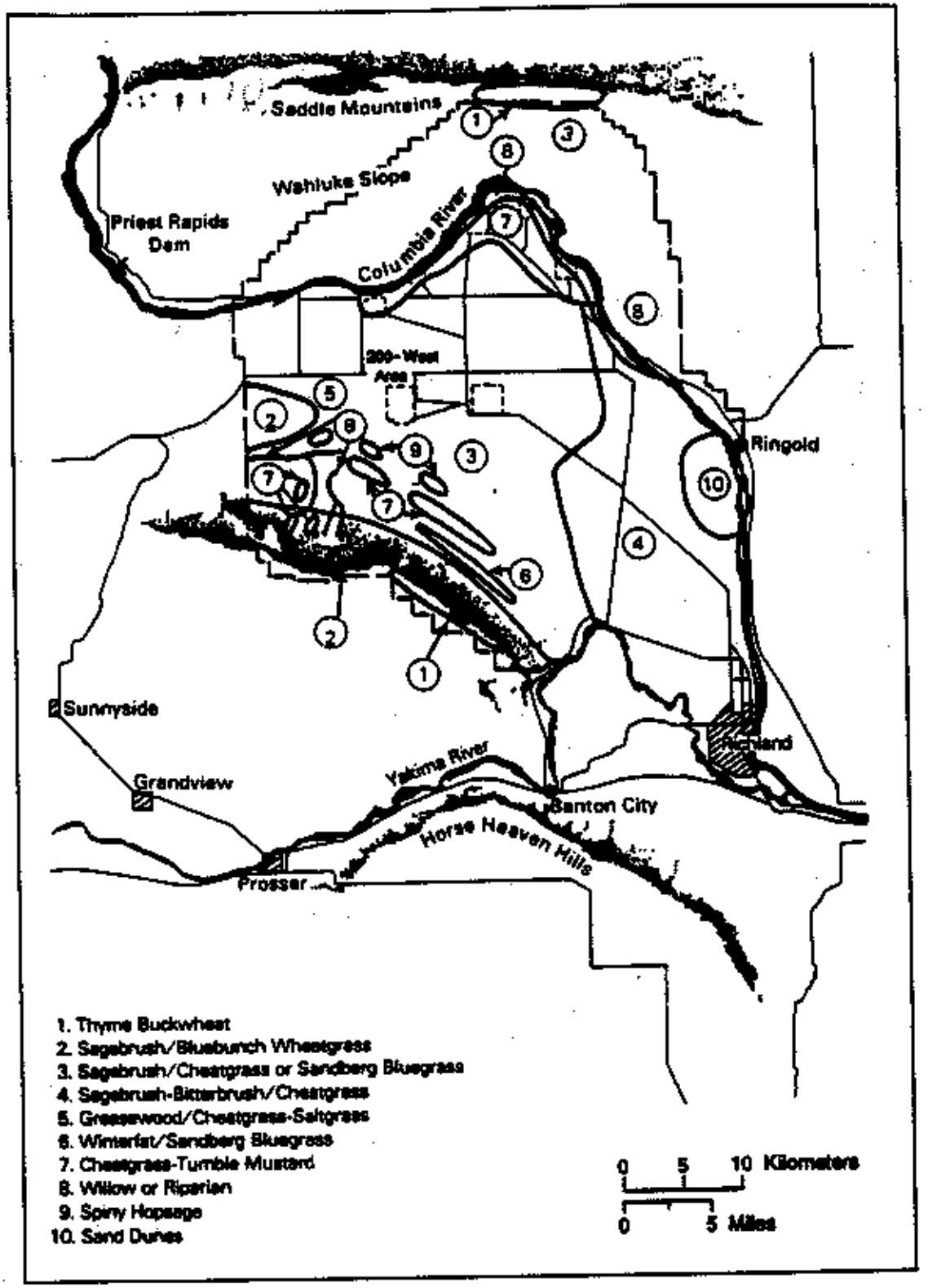

FIGURE I.12 Distribution of Vegetation Types on the Hanford Site (Source: Modified from Pacific Northwest Laboratory 1991, Figure 5.2)

I.4 THREATENED AND ENDANGERED SPECIES

Species listed as threatened or endangered and candidate species and species under status review (see Section I.5) potentially occurring in areas that could be affected by the remedial action alternatives were identified through informal consultations with the U.S. Fish and Wildlife Service (Tieger 1988; Brabander 1990, 1991, 1992; Gloman 1991; Johnson 1991; Benton 1992; Charbonneau 1992; Flotlin 1992), the MDOC (Dickneite 1988, 1991; Gaines 1988; Dieffenbach 1990; Figg 1991); and the Utah Department of Natural Resources (Fairchild 1991). Letters of consultation with the U.S. Fish and Wildlife Service are reproduced in Appendix J of this FS.

The term critical habitat for a threatened or endangered species means the specific areas within the geographical area occupied by the species on which are found those physical or biological features essential to the conservation of the species and which may require special management considerations or protection. Designated critical habitat may also include specific areas outside the geographical area occupied by the species that have been determined by the Secretary of the Interior (or Commerce) to be essential for conservation of the species.

I.4.1 Weldon Spring Site

I.4.1.1 Bald Eagle (*Haliaeetus leucocephalus*) — Endangered

The bald eagle is listed as endangered in Missouri. This bird of prey inhabits much of North America from the Arctic to the Gulf of Mexico. Generally, this species nests within 0.8 km (0.5 mi) of water and feeds on fish and waterfowl. Populations of this once common species declined since the mid 1800s because of factors such as pesticides in prey, habitat loss and fragmentation, and hunting. Since the species was listed (1967), populations in some areas (e.g., Wisconsin and Michigan) have been increasing. The bald eagle is known to occur at the Busch Wildlife Area where it is an uncommon spring and fall visitor (MDOC 1991). Bald eagles use the Howell Island Wildlife Area as a roost site in winter (Gaines 1988; Brabander 1992). The bald eagle has been sighted in St. Charles County on the last six bald eagle winter counts, and an average of 25 have been sighted in the county each year. No suitable or designated critical habitat for this species has been identified at the chemical plant area or at areas proposed for remediation under the current action.

I.4.1.2 Peregrine Falcon (*Falco peregrinus*) — Endangered

Peregrine falcons are typically found near wetlands (rivers, marshes, estuaries, and shorelines) and in open country. They feed principally on songbirds, shorebirds, and waterfowl, capturing their prey on the wing. Foraging occurs over large areas. The peregrine falcon nests on cliff faces, river banks, in abandoned raptor nests, and on buildings. Like bald eagles, peregrine populations have been seriously affected in the past by pesticide use, particularly DDT (dichlorodiphenyltrichloroethane). Captive breeding programs and a ban on DDT use have

contributed to the reestablishment of peregrine populations nationwide. Transient occurrences of peregrine falcons have been reported from St. Charles County (Gaines 1988), and the species is considered a casual spring and fall visitor at the Busch Wildlife Area but is not observed every year (MDOC 1991). The nearest hack site is located about 48 km (30 mi) east of the chemical plant in downtown St. Louis (Charbonneau 1992). No designated critical habitat for this species has been identified in the vicinity of the chemical plant area.

I.4.1.3 Interior Least Tern (*Sterna antillarum*) — Endangered

Least terns nest on bare to sparsely vegetated beaches, including salt flats, sand and gravel bars, spits, and islands (U.S. Fish and Wildlife Service 1988). Small nesting colonies occur on large open sandbars along the Mississippi River in Missouri (MDOC 1984). At one time, nesting also occurred along the Missouri River (MDOC 1984). Populations of this species have been declining as a result of habitat loss and degradation following dam construction, stream channelization, and water withdrawals for irrigation (MDOC 1984; U.S. Fish and Wildlife Service 1988). Transient occurrences of this bird have been reported during the summer from St. Charles County (Gaines 1988). It is known to visit the Busch Wildlife Area where it is considered a casual spring and fall visitor that may not be observed every year (MDOC 1991). The least tern forages on small fish and insects. No nesting habitat is known in the Missouri River in the vicinity of the Weldon Spring site (Charbonneau 1992), and no designated critical habitat exists at the chemical plant area, although migratory individuals may forage at the on-site wetlands and the off-site lakes.

I.4.1.4 Pallid Sturgeon (*Scaphirhynchus albus*) — Endangered

The pallid sturgeon is a large bottom-dwelling fish found primarily in large turbid rivers, where it lives in strong currents over areas with sandy or gravelly bottoms. In Missouri, this species is restricted to the Missouri River and to a small section of the Mississippi River from its confluence with the Missouri River to a few miles upstream (Pflieger 1975). Although little is known about the life history of this species, spawning is between early June and early August (Pflieger 1975). It feeds on aquatic insects and small fish. The pallid sturgeon has been reported from the Missouri River near the Weldon Spring site (Gaines 1988; Brabander 1992). This species has been reported from the Missouri River at the U.S. Route 40/61 crossing of the Daniel Boone Bridge (Gaines 1988), approximately 5 km (3 mi) downstream of the confluence of the Southeast Drainage with the Missouri River (Gaines 1988; MDOC 1989).

I.4.1.5 Decurrent False Aster (*Boltonia decurrens*) — Threatened

The decurrent false aster (known as "starwort" in Missouri) is a composite that can be found on alluvial soils bordering sloughs, ditches, ponds, and streams. It has been reported from St. Charles County at two locations along the Missouri River (Figg 1991). The decurrent false aster has not been documented from the Weldon Spring area and is not expected to occur at the chemical plant area (Brabander 1992).

I.4.2 Wentzville Rail Siding

No listed species are expected to occur at the Wentzville rail siding (Brabander 1991).

I.4.3 Envirocare Site

I.4.3.1 Bald Eagle (*Haliaeetus leucocephalus*) — Endangered

The bald eagle is listed as endangered in Utah, where it is primarily a winter resident. Two active nests have been documented in the southeastern portion of Utah, and the state supports one of the largest wintering populations of bald eagles in the country (Johnson 1991). Birds usually begin arriving in mid November and leave by March. Rush Valley — located about 48 km (30 mi) east of the Envirocare site — supports one of the largest concentrations of bald eagles in Utah; as many as 200 birds have been counted in this area. Skull Valley, about 24 km (15 mi) east of the Envirocare site, supports a smaller number of wintering bald eagles. No eagles are known to overwinter in the immediate vicinity of the Envirocare site and no designated critical habitat is present at the site; this species possibly occurs in the general vicinity of the potential disposal cell.

I.4.3.2 Peregrine Falcon (*Falco peregrinus*) — Endangered

The endangered peregrine falcon is uncommon in Utah. The Utah Division of Wildlife Resources and the Peregrine Fund (Boise, Idaho) have been attempting to reintroduce this species to the state (Johnson 1991). Hack towers have been erected around the Great Salt Lake in an effort to establish a core population in the surrounding marshes (Johnson 1991). One hack site constructed on the north end of the Stansbury Mountains near Timpie, Utah, now supports a nesting pair of peregrine falcons that are returning to use the box. This site is approximately 42 km (26 mi) east of the Envirocare site. A second hack site, on Antelope Island about 89 km (55 mi) northeast of the site, is also being used by a pair of falcons. No nesting habitat for this species occurs at the Envirocare site.

I.4.4 Hanford Site

I.4.4.1 Bald Eagle (*Haliaeetus leucocephalus*) — Threatened

The bald eagle is listed as threatened in Washington. It is a winter resident along the Columbia River, feeding on dead salmon and waterfowl, but it does not nest on the Hanford site. From 1980 to 1990, the number of wintering eagles ranged from 35 to 55; one-third to one-half of these were adults. A bald eagle roost has been documented on the Columbia River at a point 16 km (10 mi) north of the 200 Area (Flotlin 1992). Although no inland surveys have been conducted for bald eagles, they are not expected to occur near the 200-West Area because

of the absence of suitable foraging or roosting habitat in the area and because of the distance (about 8 km [5 mi]) from the Columbia River.

I.4.4.2 Peregrine Falcon (*Falco peregrinus*) — Endangered

The peregrine falcon is an occasional spring and autumn migrant through the Hanford area, but it does not nest there. Old records indicate that there were 12 historic nest sites in the Hanford area (DOE 1991). Currently, seven nesting pairs are present in the state of Washington. In winter, total numbers increase as migrants pass through the area. No inland surveys have been conducted for peregrine falcons; however, their prey is usually associated with the Columbia River (DOE 1991). As a result, the 200-West Area is not likely to be used by peregrine falcons, although some birds might venture inland from the Columbia River in search of songbirds.

I.5 CANDIDATE SPECIES OR SPECIES UNDER STATUS REVIEW

The species described in Sections I.5.1 and I.5.4 have been classified as Category 2 (C2) species by the U.S. Fish and Wildlife Service (1991b). A taxon is listed as C2 when the Fish and Wildlife Service has information that indicates that proposing to list the species as endangered or threatened is possibly appropriate but conclusive data on biological vulnerability and threat are not currently available. Taxa classified as C2 are considered to be candidates for possible addition to the *List of Endangered and Threatened Wildlife* (U.S. Fish and Wildlife Service 1991a). The status of the long-billed curlew (see Section I.5.4.1) has recently been changed from C2 to 3C; a 3C status indicates that the taxon has proven to be more abundant or widespread than previously believed and/or is not subject to any identifiable threat.

I.5.1 Weldon Spring Site

I.5.1.1 Sicklefin Chub (*Macrohybopsis meeki*) — C2 Status

The sicklefin chub occurs throughout the Missouri River and in the Mississippi River downstream from the Missouri (Pflieger 1975). This small fish (<10 cm [4 in.]) is restricted to the main channels of large turbid rivers with a bottom of sand or fine gravel. Although this species is presumed to be a bottom feeder, little is known about its food habits (Pflieger 1975). Because of its numerous taste buds, the sicklefin chub is thought to be a specialist feeder, locating food by taste. Young have been collected from the Missouri River in July, suggesting that spawning is likely to be in spring (Pflieger 1975). This species occurs in the Missouri River in the vicinity of the Weldon Spring site (Brabander 1992). The sicklefin chub has been reported from the Missouri River at the U.S. Route 40/61 Daniel Boone Bridge, about 5 km (3 mi) downstream of the confluence of the Southeast Drainage with the Missouri River (Gaines 1988; MDOC 1989); near Pelican Island in St. Charles County, about 45 km (28 mi) downstream from the

mouth of the Southeast Drainage (Figg 1991); and 1.6 km (1.0 mi) north of Creve Coeur Airport in the Missouri River in St. Charles County (Figg 1991).

I.5.1.2 Sturgeon Chub (*Macrohybopsis gelida*) — C2 Status

The distribution and habitat requirements of the sturgeon chub are very similar to the sicklefin chub. This small fish (<8 cm [3 in.]) does not enter tributary streams, and it is not found in the Mississippi River north of its confluence with the Missouri River. Neither the feeding behavior nor the reproductive habits of this species are known (Pflieger 1975). Like the sicklefin chub, the sturgeon chub occurs in the Missouri River in the vicinity of the Weldon Spring site (Gaines 1988; Figg 1991; Brabander 1992). It has been reported from the Missouri River near the U.S. Route 40/61 Daniel Boone Bridge (Gaines 1988) and near Pelican Island in St. Charles County (Figg 1991).

I.5.1.3 Alligator Snapping Turtle (*Macroclemys temminckii*) — C2 Status

The very large alligator snapping turtle is an aquatic turtle that ranges from northern Florida to southeastern Kansas, Missouri, and Illinois. The preferred habitats of this species include deep sloughs, oxbow lakes, and deep muddy pools of large rivers (Johnson 1987). This turtle spends most of its time in the muddy bottom of deep water, in root snags, and in other hiding places. At night it tends to actively forage, whereas it spends the day in hiding and in passive fishing by means of a lure-like tongue (Carr 1952). The alligator snapping turtle feeds primarily on fish, but has been known to eat small turtles. Reproductive maturity is achieved at about 11 to 13 years. Courtship and breeding occur in late spring and take place in water. The eggs, which are buried in banks above the water line, hatch in late summer (Johnson 1987). Water pollution, habitat degradation, and overharvesting have contributed to the reduced numbers of this species. The alligator snapping turtle has not been collected or observed in the Weldon Spring Wildlife area and is not expected to occur in the area because of the absence of suitable habitat (Miller 1991).

I.5.1.4 Eastern Massasauga (*Sistrurus catenatus catenatus*) — C2 Status

The eastern massasauga is one of two subspecies of the massasauga rattlesnake (Johnson 1987). In Missouri, the eastern massasauga is found in marshes or moist prairies that are within or near large river floodplains. This species is active from April through October, with much time spent basking during warm sunny days, and it feeds primarily on voles, deer mice, and small snakes. Courtship and breeding take place in spring or autumn, but litters may be produced only every other year (Johnson 1987). The distribution of this species in Missouri has become restricted to a few isolated areas in the eastern, north-central, and northwestern portions of the state as a result of habitat loss. The eastern massasauga is known from St. Charles County (Johnson 1987; Figg 1991; Brabander 1992); the nearest sighting was approximately 10 km (6 mi) north of the Weldon Spring site (Charbonneau 1992).

I.5.1.5 Bachman's Sparrow (*Aimophila aestivalis*) — C2 Status

The Bachman's sparrow ranges over the southeastern United States north to Pennsylvania and Ohio (Terres 1980). In Missouri, this species is near the northern edge of its range, where typical nesting habitat is abandoned fields dominated by goldenrods, asters, and grasses. This sparrow nests from April to July, in nests usually built on the ground and constructed primarily of fine grasses (Bent 1968). Because this bird is so secretive, little is known about its life history, particularly its courtship behavior. Bachman's sparrow forages on the ground, feeding on insects and seeds (Terres 1980). Habitat destruction and dependence on ephemeral, early-successional vegetation appear to be likely causes for its decline (MDOC 1984). This species is listed as a casual spring and summer resident at the Busch Wildlife Area, but there have been no records of breeders for at least 18 years (MDOC 1991).

I.5.1.6 Loggerhead Shrike (*Lanius ludovicianus*) — C2 Status

The loggerhead shrike is a southern Nearctic species, with a breeding range extending from southern Canada to the highlands of southern Mexico (Peterson 1980). This species inhabits semiopen country, thinly wooded or scrubby lands with clearings, meadows, pastures, old orchards with thickets, and hedges (Terres 1980). During winter, the loggerhead shrike feeds largely on mice and small birds; in summer, insects become a large component of the diet (Terres 1980). This species is identified as occurring in the Busch Wildlife Area in all seasons, sparingly recorded but generally every year (MDOC 1991), and is a probable nesting species in the area. Four loggerhead shrikes have been observed near the Weldon Spring site at the proposed borrow area (Thomas 1992).

I.5.2 Wentzville Rail Siding

No candidate (C2) species or designated critical habitats have been identified at the site of the Wentzville rail siding (Brabander 1991).

I.5.3 Envirocare Site

No candidate (C2) species have been identified as occurring at the Envirocare site (Johnson 1991).

I.5.4 Hanford Site

I.5.4.1 Long-Billed Curlew (*Numenius americanus*) — 3C Status

The status of the long-billed curlew has been changed from C2 (Gloman 1991) to 3C (Flotlin 1992), so the species is not discussed in this document.

I.5.4.2 Ferruginous Hawk (*Buteo regalis*) — C2 Status

The ferruginous hawk nests on cliffs, in trees, and on transmission towers. It is known to nest on transmission towers at the Hanford site (DOE 1991); however, these nests are more than 16 km (10 mi) from the 200-West Area (Weiss 1992). This hawk feeds on a variety of animals, including snakes and pocket gophers. A once common species, it has been declining because of conversion of native shrub-steppe habitat to agriculture, water diversion and impoundment, and urbanization. In 1987, 63 nesting pairs were reported from Washington (DOE 1991). The ferruginous hawk may forage in the 200-West Area.

I.5.4.3 Western Sage Grouse (*Centrocercus urophasianus phaios*) — C2 Status

The western sage grouse almost exclusively inhabits areas dominated by sagebrush (*Artemisia tridentata*). It prefers level to gently rolling sites with slopes of less than 30% (DOE 1991). Breeding occurs during late spring in open areas of bare (or nearly bare) ground, called leks, ranging in size from 4 to 40 ha (10 to 100 acres). These leks are usually adjacent to nesting and brood-rearing habitat, characterized by 20 to 40% cover of late-successional sagebrush. During winter, the sage grouse moves to lower elevations, free of snow, and feeds almost solely on sagebrush leaves. Throughout the year, sagebrush accounts for over 60% of its diet. Population decline has been attributed to habitat loss resulting from military training exercises, land conversion to agriculture, habitat degradation resulting from livestock grazing, and wildfire (DOE 1991). The western sage grouse population at the Hanford facility is small and appears to be confined to the slopes of the Rattlesnake Hills, about 8 km (5 mi) south of the 200-West Area (Pacific Northwest Laboratory 1991). Only one or two birds are sighted annually near Rattlesnake Hills, and no broods have been seen since 1976 (DOE 1991); however, no systematic surveys have been conducted.

I.5.4.4 Black Tern (*Chlidonias niger*) — C2 Status

The black tern nests in prairie sloughs and marshes from Canada, south to Ohio and as far east as New England, and winters along seacoasts. It nests in late spring and summer in small, loose colonies on mats of dead vegetation. The black tern forages over marshes and meadows feeding on insects. This species also forages in shallow water, feeding on small fish, crustaceans, and mollusks (Terres 1980). No black terns have been reported from the Hanford site, and the only suitable habitat in the area is likely to be along portions of the Columbia and Yakima rivers. Because of the absence of surface waters and marshes, none are expected in the 200-West Area.

I.5.4.5 Loggerhead Shrike (*Lanius ludovicianus*) — C2 Status

The loggerhead shrike is a southern Nearctic species, with a breeding range extending from southern Canada to the highlands of southern Mexico (Peterson 1980). This species inhabits semiopen country, thinly wooded or scrubby land with clearings, meadows,

pastures, old orchards with thickets, and hedges (Terres 1980). During winter, the loggerhead shrike feeds largely on mice and small birds; in summer, insects become a large component of its diet (Terres 1980). This species has been reported from sagebrush areas at the Hanford site and may utilize the 200-West Area for nesting and foraging (Pacific Northwest Laboratory 1991).

I.5.4.6 Bull Trout (*Salvelinus confluentus*) — C2 Status

Before construction of dams and the introduction of warmwater fishes, the bull trout was one of the dominant predatory fish in the Columbia basin (Li et al. 1987). The range of this large species (>9 kg [20 lb]) includes coastal and mountain streams of the Arctic, Pacific, and Missouri river drainages; it is present from the southern Yukon to the headwaters of the Columbia River drainage, northern Nevada, and the McCloud River drainage in northern California (Page and Burr 1991). The habitat of the bull trout is deep pools in large cold rivers and lakes, and the species is rarely anadromous. This, and other species, have been impacted by dam-related habitat changes and the introduction of exotic warmwater fish assemblages, although few exotics have yet become established in the Hanford Reach of the Columbia River (Li et al. 1987). The bull trout has been collected from the Hanford Reach of the Columbia River (Neitzel 1992), but no suitable habitat for this species occurs in the 200-West Area.

I.5.4.7 California Floater (*Anodonta californiensis*) — C2 Status

The California floater, a mollusk, occurs in flowing stretches of rivers in the Pacific Northwest, especially in those with a rocky bottom. It has been reported from the Snake River in Washington and Idaho but not from the Hanford Reach of the Columbia River or from the Yakima River (Neitzel 1992). No suitable habitat for this species occurs in the 200-West Area.

I.5.4.8 Columbia Pebblesnail (*Fluminicola columbianus*) — C2 Status

Like most gastropod mollusks, the Columbia pebblesnail (also referred to as the Columbia River spire snail, *Lithoglyphus columbianus*) has a 1-year life cycle. Eggs are deposited during the spring as water temperatures begin to rise. This snail occurs on and under rocks and vegetation in slow to rapid currents of streams, and it has been reported from the Hanford Reach (DOE 1991). As a result of logging, grazing, farming practices, withdrawal of water for irrigation, and dam construction on the Columbia River and its tributaries, many streams and rivers no longer contain suitable habitat for the Columbia pebblesnail (DOE 1991). Because of the absence of streams in the 200-West Area, this species would not occur in the potential project area.

I.5.4.9 Columbia Yellow-Cress (*Rorripa columbiae*) — C2 Status

The columbia yellow-cress, a member of the mustard family, is a low-growing herb found in small scattered patches along wet shorelines and islands of the Columbia River in Benton and Skamania counties, Washington (DOE 1991). No systematic surveys have been

conducted to determine the status of this species on the Hanford site. However, it is not expected to be present in the 200-West Area because of the absence of suitable habitat.

I.6 EFFECTS OF PROPOSED ACTION AND ALTERNATIVES ON SPECIES AND HABITATS

I.6.1 Alternative 1: No Action

Currently contaminated habitats at the chemical plant area total about 88 ha (217 acres). Under Alternative 1, potential exposure of some listed species and other biota to the contaminants would continue as a result of (1) direct exposure to contaminated media at existing source areas, (2) exposure of listed species to contaminants via food chain transport, and (3) movement of contaminated groundwater and surface water to areas currently unaffected by site contaminants.

No designated critical habitat for the bald eagle occurs at the site or at any of the off-site source areas. The bald eagle occurs in the area but has never been reported from the site and is not expected to frequent the site because of the absence of suitable habitat. This species might occasionally feed on fish from Lakes 34, 35, and 36 in the Busch Wildlife Area and thus could potentially be exposed to contaminants at these locations via food chain transfer. The bald eagle may also feed on waterfowl (Kozie and Anderson 1991), and food chain transfer of contaminants from waterfowl to the bald eagle (at other locations) has been previously reported in the literature (Pattee and Hennes 1983). If contaminant biouptake and bioaccumulation are occurring in waterfowl using the contaminated on-site surface waters, the bald eagle could be affected by foraging on contaminated waterfowl. Under the no-action alternative, the potential for this contaminant pathway to affect the bald eagle would continue. A similar potential exists, and would continue to exist, for food chain transfer of contaminants to the bald eagle from ingestion of contaminated carrion or hunter-killed game, such as raccoon, pheasant, turkey, and rabbit (Craig 1990); from ingestion of contaminated media such as surface water; or from absorption across body surfaces.

The interior least tern could potentially be affected by contaminants present in the sediment of some off-site lakes. This species could be exposed while foraging in contaminated areas for small fish and insects, through direct dermal contact and/or ingestion of contaminated media, and through food chain transfer from prey inhabiting contaminated sediment. Because of the infrequent occurrence of this species in the area and the apparent absence of biouptake of contaminants in off-site biota, as indicated by studies conducted to date (DOE 1992b), few or no impacts are anticipated to this species. However, under Alternative 1, the potential for contaminant exposure of and adverse effects to the interior least tern would continue.

The peregrine falcon might be exposed through food chain transfer to site contaminants by feeding on other bird species that utilize the chemical plant area for foraging, nesting, and roosting (e.g., starling, pigeon, and house sparrow). The transient nature of the peregrine falcon

in the area suggests a very limited contaminant exposure potential for this species, but this limited exposure potential would continue under the no-action alternative.

The pallid sturgeon, sicklefin chub, and sturgeon chub have been reported from the Missouri River and could be exposed to contaminants from the Southeast Drainage. Neither the occurrence of these species in the Missouri River in the vicinity of the Southeast Drainage, nor the concentrations of all contaminants in the Missouri River at this location, are known. The pallid sturgeon and the sicklefin and sturgeon chubs are restricted to large rivers and are not expected to enter the Southeast Drainage. Thus, these species are not expected to be directly exposed to the contaminants in this drainage. These species might, however, be exposed to contaminated sediment and surface water entering the Missouri River from the Southeast Drainage (e.g., during storm events), and under Alternative 1 the potential for such exposure would continue. Similarly, the bald eagle is not expected to utilize the Southeast Drainage directly but might forage at or near its mouth and thus be exposed to site contaminants entering the river.

Under current conditions, only a very limited contaminant exposure potential is expected for the pallid sturgeon, sicklefin and sturgeon chubs, and bald eagle. Upstream and downstream uranium concentrations have been reported to range from 2.0 to 7.48 pCi/L and 2.0 to 9.52 pCi/L, respectively (MK-Ferguson Company and Jacobs Engineering Group 1990, 1991, 1992a), whereas the maximum reported surface water concentration within the Southeast Drainage is 1,200 pCi/L. These data suggest that dilution within a short distance downstream of the inflow of the Southeast Drainage will greatly reduce the surface water concentrations of any contaminants entering the Missouri River from the drainage and thus reduce the potential for adverse affects to the listed biota and other species that might be present.

The radiation dose to freshwater fish from exposure to contaminated water and sediment at the confluence was estimated with conservative assumptions (Monette 1992; DOE 1992a): (1) the radionuclides in each series are in secular equilibrium, (2) the energy liberated by each decay series within tissues is totally absorbed by the organism, (3) radioactive contaminants are distributed homogeneously within tissues, (4) organisms are continuously exposed to the maximum radionuclide concentration reported in water samples from each water body, and (5) all measurements below analytical detection limits are equal to the detection limit. Using these assumptions, the resulting estimated dose to fish (such as the pallid sturgeon) is less than the limit of 1 rad/d specified in DOE Order 5400.5 for the protection of native aquatic organisms.

I.6.2 Alternative 6a: Removal, Chemical Stabilization/Solidification, and Disposal On-Site

The removal of contaminated soil, surface water, sediment, and vegetation at the chemical plant area would prevent the future exposure of biota to contaminated media. Some permanent loss of wildlife habitat would result from the implementation of this alternative; however, no designated critical habitats for any of the listed, candidate, or review species would be disturbed. Excavation of contaminated source areas would disturb approximately 55 ha

(137 acres) on-site and fewer than 2 ha (5 acres) at the off-site areas. Following completion of all remedial activities under this alternative, permanent loss of habitat would be limited to the disposal cell area of approximately 17 ha (42 acres).

Potential impacts to local biota could occur under Alternative 6a as a consequence of (1) excavation of contaminated source areas, (2) construction and operation of the treatment and volume reduction facilities, and (3) construction and operation of the disposal cell. Excavation activities at the site are not expected to impact any endangered, threatened, or C2 species because no listed or C2 species are known to exist in or utilize the source areas. Similarly, no impacts to listed or C2 species are anticipated from the construction and operation of the treatment and volume reduction facilities or the disposal cell. No construction or excavation activities would either occur in or affect habitats in the Missouri River in any way; thus, no impacts to the pallid sturgeon, sickelfin chub, and sturgeon chub are anticipated under Alternative 6a. In addition, any impacts associated with excavation and construction activities would be temporary. Good engineering practices and appropriate mitigative measures would be used during all excavation and construction activities to prevent or minimize potential erosion, dust emissions, and contaminant releases.

Remedial action activities at the site could potentially disturb overwintering bald eagles using the Howell Island Wildlife Area as a roost site. However, such impacts are expected to be minimal because the distance from the chemical plant to Howell Island is approximately 3,200 m (10,600 ft) and the response of bald eagles to human activities has been shown to be strongly and inversely related to distance. Grubb and King (1991) assessed the effects of human disturbance on breeding bald eagles and reported the following median distances that evoked response from human disturbance: 300 m (980 ft) resulted in an "awareness" or alert response, 150 m (490 ft) resulted in a short distance flight, and 100 m (330 ft) caused departure from the immediate area of human activity. Grubb and King (1991) suggested that vehicles be excluded within at least 450 m (1,500 ft) and restricted within 850 m (2,800 ft) of breeding eagles. The distance from the chemical plant area to Howell Island is about 32 times greater than the minimum median distance reported by Grubb and King (1991) to prompt the departure of bald eagles from an area of human activity, 10 times greater than the median distance that evoked an alert response, and almost 4 times greater than the distance recommended for vehicle restrictions. Thus, human activities at the chemical plant area are not expected to disturb overwintering bald eagles at Howell Island. In addition, many of the types of pedestrian activities shown to affect eagle behavior — such as walking, hiking, hunting, and fishing (Grubb and King 1991) — are typical of visitors to the Weldon Spring and Howell Island wildlife areas.

Potential impacts to local biota (including listed and C2 species) could occur if the cell failed and no corrective measures were taken to prevent the release of contaminants to the environment. A monitoring well system would be installed to allow for the prompt detection of any localized releases from the disposal cell, and contingency plans would be developed and would be applied to rapidly address any releases. A leachate collection and removal system in the disposal cell would provide additional monitoring of the disposal cell and early detection of potential leachate migration. In addition, concentrations of some of the contaminants in the

TABLE I.4 Estimated Leachate Concentrations for Chemically Stabilized/Solidified Sludge and Quarry Soil[a]

Contaminant	Estimated Leachate Concentration (mg/L)		Maximum Leachate Concentration Allowed[c] (mg/L)
	Raffinate Pit Sludge[b]	Quarry Soil	
Arsenic	0.218	<0.013	5.0
Barium	10.9	0.669	100.0
Cadmium	0.003	<0.002	1.0
Chromium	0.126	0.082	5.0
Lead	<0.018	<0.018	5.0
Mercury	<0.0002	<0.0004	0.2
Selenium	0.061	<0.019	1.0
Silver	0.012	<0.004	5.0
NB	<0.020	0.813	2.0
2,4-DNT	<0.020	0.017	0.13

[a] Concentrations in leachate are based on toxicity characteristic leachate procedure (TCLP) testing of raffinate pit sludge spiked with the historical high concentrations of contaminants and quarry soil spiked with the historical high concentration of nitrobenzene. Samples were stabilized/solidified using the blend formula determined by Gilliam and Francis (1989) and cured for 28 days.

[b] Sludge samples were taken from each pit. The highest leachate concentration is reported here.

[c] TCLP limits; see Appendix G, Table G.3 of this FS.

Source: Waste Technologies Group (1992).

leachate from the treated materials would be below the criteria used to determine whether a waste is a characteristic hazardous waste (Table I.4). Thus, impacts to listed species (and other biota) would be minimized in the event of a release of contaminants or leachate from the disposal cell.

Under a scenario that assumes future loss of institutional controls and failure of the disposal cell cover without corrective measures, contaminants could be dispersed to the environment as a result of transport from the cell by wind or water (rain). However, prior to placement in the disposal cell, the most highly contaminated material would have been treated by chemical stabilization/solidification, thereby decreasing the mobility of the contaminants and increasing the resistance of the material to degradation and transport by wind or water.

Positive impacts to listed and C2 species would be incurred as a result of the removal, treatment, and disposal of the contaminated materials under Alternative 6a. Excavation of the source areas would remove the contaminated material from direct exposure to the environment,

and chemical stabilization/solidification would reduce contaminant mobility. In addition, the site wastes would be isolated from the environment by containment in an engineered disposal cell, which would further limit contaminant mobility.

I.6.3 Alternative 7a: Removal, Vitrification, and Disposal On-Site

Impacts to biota under Alternative 7a would be similar in nature, magnitude, and duration to those identified for Alternative 6a; impacts would result primarily from excavation and construction activities, and treatment of contaminated materials. Alternative 7a would be similar to Alternative 6a because the same source areas would be excavated and similar on-site areas would be temporarily disturbed by construction activities. The excavation of source areas would disturb approximately 55 ha (137 acres) on-site and less than 2 ha (5 acres) at the off-site areas, and permanent loss of habitat would be limited to the disposal cell area of approximately 17 ha (42 acres). As for Alternative 6a, excavation, construction, and treatment activities under Alternative 7a are not expected to disturb any listed species. Because of the distance of the Howell Island bald eagle winter roost area to the chemical plant, no disturbance of bald eagles from human activities at the Weldon Spring site is anticipated. No construction or excavation activities would occur in or affect habitats in the Missouri River in any way; thus, no impacts to the pallid sturgeon, sickelfin chub, and sturgeon chub are anticipated under Alternative 7a.

Good engineering practices and appropriate mitigative measures would be used during all excavation and construction activities to prevent or minimize potential erosion, dust emissions, and contaminant releases. No impacts to local biota are anticipated from off-gas releases during contaminant vitrification. The off-gas treatment system would consist of air pollution treatment and control devices (such as scrubbers and HEPA filters) and would be used at all times during vitrification.

Alternative 7a would result in the temporary disturbance of about 13,000 m^2 (140,000 ft^2) of land along a 5.3-km (3.3-mi) route in the Weldon Spring Wildlife Area that would not be disturbed under Alternative 6a. This land is necessary for a natural gas pipeline that would be constructed to fuel the vitrification process. Construction of the pipeline, which would parallel State Route 94 (Figure I.3), could temporarily disturb habitat used by the loggerhead shrike, a C2 species that occurs at the wildlife area and has been observed in the vicinity of the proposed pipeline (Thomas 1992). This area may also be used by Bachman's sparrow, although no sightings of this species have been reported along the proposed pipeline area. Impacts to these species, if any, would primarily result from construction noise and human activity. However, because of the close proximity of State Route 94, this area receives considerable traffic and human activity. Thus, the potential temporary impacts from the pipeline construction are expected to be minor and not result in any adverse effects to either the loggerhead shrike or Bachman's sparrow. Following completion of the pipeline, the disturbed areas would be restored to original contours and revegetated.

As for Alternative 6a, a monitoring well system and a leachate collection and removal system would be installed to allow for the detection of any localized releases or leachate migration from the disposal cell. Contingency plans would be developed and in place to rapidly

address any releases. In addition, concentrations of some of the contaminants in the leachate from the treated materials would be below the criteria used to determine whether a waste is a characteristic hazardous waste (Table I.5). Under a scenario that assumes loss of institutional controls and failure of the disposal cell cover, contaminants could be dispersed to the environment as a result of transport from the cell by wind or water (rain). However, prior to placement in the disposal cell, the most highly contaminated material would have been vitrified, thereby destroying some contaminants, decreasing the mobility of all remaining contaminants, and increasing the resistance of the material to degradation and transport by wind or water.

Alternative 7a would result in the same positive environmental impacts as those identified for Alternative 6a. Vitrification would destroy organic contaminants in some of the treated material and would result in a significant reduction in contaminant mobility. As with the chemically treated waste product, contaminant concentrations in leachate from the vitrified materials would be below the criteria used to determine whether a waste is a characteristic hazardous waste (Table I.5). The site wastes would be isolated from the environment by containment in an engineered disposal cell, which would further limit contaminant mobility. Off-gas emissions from the vitrification process could potentially increase impacts to local biota (including some listed and C2 species). However, impacts are expected to be minimal because extensive off-gas controls (scrubbers and HEPA filters) would be used.

TABLE I.5 Estimated Leachate Concentrations for Vitrified Sludge and Site Soil

Contaminant	Estimated Leachate Concentration[a] (mg/L)		Maximum Leachate Concentration Allowed[b] (mg/L)
	ISV Glass	JHCM Glass	
Arsenic	<1	<1	5.0
Barium	0.04	0.04	100.0
Cadmium	0.01	<0.01	1.0
Chromium	<1	<1	5.0
Lead	<1	<1	5.0
Mercury	<0.03	<0.03	0.2
Selenium	<0.01	<0.01	1.0
Silver	<0.1	<0.1	5.0

[a] Concentration determined from a previous study of raffinate pit sludge and site soil with a modified extraction procedure (EP) toxicity test; further testing (TCLP) of similar waste to be conducted at other DOE facilities within the next several years will provide additional leachability data for vitrification. ISV = in-situ vitrification; JHCM = joule-heated ceramic melting.

[b] TCLP limits; see Appendix G, Table G.3 of this FS.

Source: Koegler et al. (1989).

J.6.4 Alternative 7b: Removal, Vitrification, and Disposal at the Envirocare Facility

Impacts to listed species could result from four sources: (1) excavation, construction, and treatment activities at the Weldon Spring site; (2) construction and operation of a rail siding at Wentzville; (3) construction and operation of a disposal cell at the Envirocare facility; and (4) transfer of contaminated media from the railcars to the disposal cell. Excavation, construction, and treatment activities at the Weldon Spring site under Alternative 7b would be similar in nature, magnitude, and duration to those identified for Alternative 7a. In addition, although no disposal cell would be constructed on-site under this alternative, an area similar to that targeted for the cell under Alternative 7a would be temporarily disturbed because site structures and other contaminant sources would be removed from that location and it would then be used as the staging area to support waste transport off-site. Implementation of Alternative 7b would also require the construction of a rail siding in Wentzville, Missouri. No federal-listed species occur in the area, and none would be expected to be impacted by the construction and operation of the rail siding.

Construction of a disposal cell at the Envirocare facility would destroy approximately 17 ha (42 acres) of semidesert shrubland (shadscale and gray molly). No wetlands or floodplains occur at the site. Existing vegetation and some wildlife at the site would be destroyed, other wildlife using the area would be permanently displaced, and wildlife in nearby areas would be temporarily disrupted during cell construction. Waste-handling activities (unloading waste containers at the rail siding and transporting containers to the disposal cell) would result in only an incremental increase in disturbance to local wildlife from human activities.

No impacts to the bald eagle and peregrine falcon are anticipated from activities at the Envirocare facility. No designated critical habitat, roost sites, or nesting areas exist at, or in the vicinity of, the Envirocare facility. Two peregrine falcon hack sites are located 42 km (26 mi) east and 88 km (55 mi) northeast of the facility. Because of the distances from the Envirocare facility to these areas, no impacts are anticipated to peregrine falcons at these hack sites.

Disturbance to bald eagles from activities at the Envirocare facility is expected to be minor. The bald eagle is known to winter in Skull Valley and Rush Valley, 24 km (15 mi) and 48 km (30 mi), respectively, east of the Envirocare facility. These distances are more than 200 times greater than the 100-m (330-ft) distance from human activity reported by Grubb and King (1991) to prompt departure by eagles from the immediate area. These distances are also 80 and 160 times greater, respectively, than the median distances reported for human activities to evoke an alert response by bald eagles and more than 25 times greater than the distance recommended for vehicle restrictions to minimize bald eagle disturbance (Grubb and King 1991).

Given the possibility of lengthy foraging trips by the bald eagle and peregrine falcon, individuals could potentially forage in the vicinity of the proposed disposal cell and be exposed to the treated materials; also, the construction of the disposal cell could eliminate approximately 17 ha (42 acres) of foraging area for these species. The impacts from exposure and loss of foraging area would be minimized because (1) current and future activities at the Envirocare facility will likely preclude the use of the immediate surroundings by the eagle or peregrine falcon, (2) many of the Weldon Spring contaminants would be physically bound in a vitrified

product and have a very low mobility potential, and (3) the vitrified and untreated materials would be isolated from the environment by placement in an engineered disposal cell.

The Envirocare facility is currently operational, and waste handling, waste storage, and environmental monitoring are occurring at the site. The facility includes transfer and storage areas, decontamination facilities, and a laboratory. The current monitoring program at the Envirocare facility includes sampling of about 10 of 42 wells located around the currently existing disposal cell. Samples are routinely analyzed for contaminants that are representative of the waste types present in the cell. Similar activities would be expected for monitoring the containment effectiveness of the Weldon Spring waste.

Cell failure or the spill of a waste container during delivery to and handling at the site could cause the release of vitrified material or less contaminated material. The site is currently active in waste handling and disposal, and emergency spill and cleanup procedures are already in place; additional contingency plans might be developed for the Weldon Spring waste. In addition, the site has decontamination facilities, an analytical laboratory, and monitoring and maintenance programs. It is assumed that a leachate collection and removal system in the disposal cell would provide additional monitoring of the disposal cell integrity and early detection of potential leachate migration. In addition, the contaminant mobility from the vitrified product is extremely limited, and contaminant concentrations in leachate from the vitrified product would be very low (Table I.5). In the event of cell failure, rapid implementation of contingency procedures would be expected to limit the release of contaminants to the environment. The Union Pacific Railroad, which owns the rail line that would be used to deliver contaminants to the Envirocare facility, employs hazardous waste emergency response teams throughout its system. Information pertinent to shipment of the Weldon Spring waste (e.g., waste characteristics and emergency handling information) would be entered into the railroad computer system for access by the emergency response teams, if needed. A spill contingency plan would be developed and, in the event of a spill, an emergency response team would reload the spilled material, test the area for residual contamination, and clean the area as needed. Thus, potential impacts to listed species (and other biota) would be minimized in the event of an accidental release of contaminants or leaching from the disposal cell.

I.6.5 Alternative 7c: Removal, Vitrification, and Disposal at the Hanford Facility

Impacts resulting from activities at the Weldon Spring chemical plant area and at the Wentzville rail siding would be the same for Alternative 7c as Alternative 7b. The amount of land area impacted at the 200-West Area of the Hanford facility was assumed to be the same as at the Envirocare facility (and the Weldon Spring site). About 17 ha (42 acres) of vegetation and wildlife habitat (sagebrush/cheatgrass or Sandberg's bluegrass) would be permanently destroyed. Construction and maintenance of a disposal cell at the 200-West Area would have little effect on listed species in the area because (1) the construction activities would be temporary, (2) the appropriate breeding and foraging habitats for the listed species do not occur in the 200-West Area, and (3) the vitrified and untreated materials would be isolated from the environment in an engineered disposal cell.

The bald eagle is a winter resident at the Hanford facility and forages and roosts along the Columbia River, about 8 km (5 mi) from the 200-West Area; no known nests or territories occur at the Hanford site (DOE 1991). Although no inland surveys have been conducted for bald eagles at the site, it is unlikely to occur far from the river, especially during winter when few prey would be available in the 200-West Area. In addition, the shrub-steppe habitat present at the 200-West Area is not expected to provide suitable nesting or roosting habitat (large trees) for this species. Human activities in the 200-West Area associated with cell construction and maintenance and other activities would further limit the likelihood of the bald eagle foraging in the area of the disposal cell.

Disturbance to bald eagles along the Columbia River from construction and disposal activities at the 200-West Area is expected to be slight. The distance from the Columbia River to the 200-West Area is approximately 8 km (5 mi), which is about 80 times greater than the 100-m (330-ft) distance from human activity reported to prompt departure by eagles from the immediate area and more than 25 times greater than the median distance reported for human activities to evoke an alert response by bald eagles (Grubb and King 1991). Thus, construction and disposal activities at the 200-West Area are not expected to affect wintering bald eagles along the Columbia River.

No inland surveys of the 200-West Area have been conducted for the peregrine falcon. The peregrine falcon, a transient migrant, would be expected to forage near and along the Columbia River and to avoid the disposal cell area because of human activity. Furthermore, this species is not expected in the area during the summer when cell construction would occur. At the Hanford facility, the western sage grouse (C2) population is small and appears to be confined entirely to the slopes of the Rattlesnake Hills (Pacific Northwest Laboratory 1991), about 8 km (5 mi) south of 200-West Area. The construction and maintenance of a disposal cell at the 200-West Area is not expected to impact these birds because of the distance involved.

The ferruginous hawk (C2) could be impacted by the conversion of 17 ha (42 acres) of shrub-steppe habitat. Loss of this habitat type has been cited as one factor contributing to the decline of ferruginous hawk populations (DOE 1991). Because no recent surveys have been conducted for this species, its present status at the Hanford site in general, and at the 200-West Area in particular, is not known. Columbia yellow-cress (C2) occurs in wet areas along the Columbia River. The 200-West Area is primarily shrub-steppe habitat with little or no surface water present. Thus, there appears to be no suitable habitat for this species in the 200-West Area, and the Columbia yellow-cress would not be expected to occur at this location (DOE 1991). The loggerhead shrike may occur in the 200-West Area (Pacific Northwest Laboratory 1991) and could be temporarily disturbed by construction and waste disposal activities. Disturbance due to construction noise and human activity would be temporary and cease following closure of the disposal cell. Construction of a disposal cell would destroy approximately 17 ha (42 acres) of shrub-steppe habitat that could be used by this species for nesting and foraging.

Three C2 species identified as potentially occurring at the Hanford site — the bull trout, California floater, and Columbia pebblesnail — are aquatic species confined to the Columbia River. Consequently, they would not be affected by the construction of a disposal cell at the

200-West Area or by disposal activities at this location. No marshes or meadows occur in the 200-West Area and, in the absence of these habitats or other surface waters, the black tern (C2) is not expected to occur in the area or be impacted by cell construction and waste disposal activities.

Cell failure or the spill of a waste container during delivery to or handling at the site could cause the release of vitrified material or less contaminated materials. Spill contingency plans would be expected to be in place to address accidental spills or cell failure and, in the event of cell failure, rapid implementation of emergency procedures would be expected to limit the release of contaminants to the environment. In addition, the contaminant mobility from the vitrified product is extremely limited and, with prompt cleanup, an accidental spill of such material would pose little, if any, threat to biota (listed or not). A monitoring well system would be in place to detect any localized releases from the disposal cell, and contingency plans would have been developed and in place to rapidly address any releases. It is assumed that a leachate collection and removal system in the disposal cell would provide additional monitoring of the disposal cell integrity and early detection of potential leachate migration. In addition, the contaminant mobility from the vitrified product is extremely limited and contaminant concentrations in leachate from the vitrified product would be very low (Table I.5). Thus, impacts to listed species (and other biota) would be minimized in the event of an accidental release of contaminants or leaching from the disposal cell.

I.7 MITIGATION AND MONITORING

Mitigative measures that would be used at the Weldon Spring site in implementing any of the final action alternatives (6a, 7a, 7b, and 7c) are summarized in Table I.6. These measures would provide a high degree of effectiveness in minimizing the potential for adverse environmental effects associated with the excavation, construction, hauling, and treatment activities that would occur at the site. For activities related to the construction, operation, and closure of a disposal cell, it is expected that similar measures would be implemented at the off-site facilities.

Mitigative measures for protecting air quality — such as wetting surfaces, using chemical dust suppressants, and covering stockpiles and loads during transportation — would be implemented to control fugitive dust. The off gas generated during the vitrification process would be collected and treated. Air quality would be intensively monitored for all action alternatives to assess compliance with all pertinent air quality standards and ensure that appropriate controls could be applied in a timely manner, if needed.

Mitigative measures and good engineering practices would be used in all excavation and construction areas to control surface water runoff, erosion, and transport of sediment or contaminants from exposed areas. These measures would include using silt fences and straw bales downstream of work areas, covering stockpiles and exposed areas, constructing siltation ponds, and constructing berms to isolate work areas and direct the surface flow of water. All runoff from contaminated areas would be retained in siltation ponds, sampled for contamination, and treated in the site water treatment plant before release, if necessary.

TABLE I.6 Major Monitoring and Mitigative Measures for the Action Alternatives

Factor	Potential Impact or Area of Concern	Mitigative Measure
Construction and excavation activities	Transport of uncontaminated soil to nearby surface water and wetlands	Good construction practices would be implemented, including sediment barriers, dikes, siltation ponds, and drainage channels to direct runoff away from downstream or downgradient surface waters and wetlands, with surface grading and revegetation upon completion of excavation.
	Transport of contaminated surface soil to nearby surface water and wetlands, runoff of contaminated surface water, and possible impacts of leaching of contaminants to groundwater	Good construction practices would be implemented, as described above. In addition, groundwater, surface runoff, surface water, and sediment would continue to be monitored for chemical and radioactive contaminants so that contaminated media would be collected for subsequent management, including treatment of any contaminated water before release off-site.
	Loss of aquatic and terrestrial habitats	Habitats would be restored, as appropriate. The final form of mitigation would be determined in consultation with appropriate state and federal agencies.
	Disturbance of local biota, area residents, and recreational visitors by noise and remedial action activities	Vehicle and equipment mufflers would be checked periodically and maintained in good condition.
	Disturbance of local biota, area residents, and recreational visitors and impacts to local air quality as a result of fugitive dust emissions	Dust would be controlled using wet methods and/or covers at the site, along the haul roads, at storage and staging areas, and at off-site construction and excavation areas. Chemical dust suppressants would be used if needed. Work areas would be covered, as needed, e.g., at night and during high winds.
	Radon and particulate emissions	Engineering controls — such as reducing working surface areas and using covers, water, or chemical agents — would be applied, as needed, to reduce radon and particulate emissions. Air would be monitored continuously through all phases of the action period.
Transport of contaminated material from vicinity properties to the site	Accidental spill (release) of contaminated material as a result of equipment failure or vehicular accident	Waste would be transported in covered trucks traveling at low speeds. Contingency plans would be in place to address any spills that might occur during waste transport.

TABLE L6 (Cont.)

Factor	Potential Impact or Area of Concern	Mitigative Measure
Transport of contaminated material from vicinity properties to the site (cont.)	Inadvertent transport of contaminated material on haul vehicle surfaces or tires leaving controlled areas	Haul vehicles would be decontaminated and inspected before leaving the site or off-site excavation areas.
Excavation of off-site borrow material	Erosion of soil, with transport to nearby surface water and wetlands	Good construction practices would be implemented, including sediment barriers and siltation ponds, as needed.
	Disturbance of local biota, area residents, and recreational visitors by noise	Vehicle and equipment mufflers would be checked periodically and maintained in good condition.
	Disturbance of local biota, area residents, and recreational visitors and impacts to local air quality as the result of fugitive dust emissions	Dust would be controlled using wet methods at the borrow area and along the haul road. Chemical dust suppressants would be used if needed.
Transport of borrow materials and supplies to the site	Inadvertent transport of contaminated material from the site on the haul vehicle surfaces or tires	Trucks hauling borrow material would not enter contaminated areas on the site.
Transport of waste to an off-site disposal location	Accidental spill (release) of contaminated material as a result of equipment failure or vehicular accident	Waste would be transported in closed containers. Contingency plans would be in place to address any spills that might occur during waste transport.
	Inadvertent transport of contaminated material on haul vehicle surfaces or tires leaving controlled areas	Haul vehicles and containers would be decontaminated and inspected before leaving any contaminated areas.
All phases of active remedial activities	Protection of workers	All activities would be conducted in accordance with project health and safety plans and would include continuous monitoring of the work environment and the use of protective equipment, as needed.

TABLE I.6 (Cont.)

Factor	Potential Impact or Area of Concern	Mitigative Measure
All phases of active remedial activities (cont.)	Protection of the general public	Air and water would be monitored at the site and vicinity, and appropriate responses would be implemented if measured contaminant levels increased significantly above background. Access to construction and excavation areas would be limited; public vehicle access would also be limited along some of the off-site haul routes. Dust, radon, noise, and erosion controls would be applied during remedial action activities. Decontamination methods would be employed to minimize vehicle tracking of contaminants to surrounding uncontaminated areas. All traffic associated with the remedial action would be coordinated to minimize impacts on nearby facilities.
	Environmental monitoring	Air quality would be monitored for contaminated particulates and radon gas at the site perimeter. Radon would also be monitored at the nearby Francis Howell High School. Surface water and groundwater downgradient of excavation and construction areas would be monitored for chemical and radioactive contaminants, including uranium. Groundwater would also be monitored at additional on-site and off-site locations, including the perimeter of the disposal cell area. Appropriate responses would be implemented as indicated by monitoring results.
Completion of all construction and excavation activities	Environmental restoration	Remedial action areas would be restored by regrading and revegetating with native and/or forage species. Wetlands would be constructed, as indicated, on the basis of consultation with the appropriate state and federal agencies.
	Disposal site maintenance and cell integrity	An operations plan would be in place to ensure monitoring of long-term disposal cell integrity. This plan would include regular cell inspection and site vegetation control programs, handling and disposal of leachate, as well as groundwater, surface water, and air monitoring programs. Contingency plans would be developed to address any loss of disposal cell integrity and/or release of disposed materials.

Groundwater at the Weldon Spring site would be monitored before, during, and after remedial action activities. If adverse effects to groundwater were detected, appropriate contingency plans would be implemented.

Waste for off-site disposal would be transported in closed containers and carried in dedicated trains to the disposal location. Contingency plans would be in place to address spills that might occur during any phase of off-site transport. Both haul vehicles and the exteriors of the containers would be decontaminated and inspected before leaving any contaminated area. Potential impacts from off-site accidental spills would be minimized by rapidly implementing appropriate operating procedures and contingency plans.

Following completion of all construction and excavation activities, disturbed areas on-site would be backfilled and revegetated, and disturbed areas outside the site boundary would be restored to natural conditions. Habitat restoration would be carried out in consultation with appropriate state and federal agencies.

Site cleanup activities would be conducted in compliance with the site safety and health plans, DOE safety regulations, and other pertinent requirements. Prior to implementing the selected remedy, detailed plans would be provided to address (1) accidental contaminant releases to the environment, (2) emergency response procedures, (3) monitoring techniques and frequencies, and (4) various contingencies and the anticipated responses to such contingencies.

I.8 CONCLUSIONS

I.8.1 Alternative 1

Under the no-action alternative, the potential for exposure of some listed and C2 species to the contaminants would continue as a result of (1) direct exposure to contaminated media at existing source areas, (2) exposure via food chain transport, and (3) movement of contaminated groundwater and surface water to areas currently unaffected by site contaminants.

I.8.2 Alternative 6a

No adverse impacts to listed or C2 species are anticipated for Alternative 6a. Under this alternative, potential exposure of listed and C2 species in the Weldon Spring area would be reduced or eliminated for several reasons. First, contaminated soil, sediment, and other materials would be removed from on-site and off-site areas. Second, the highly contaminated materials would undergo chemical stabilization/solidification, thereby reducing contaminant mobility. Last, the treated and untreated material would be isolated from the environment in an engineered disposal cell. A program would be established to monitor contaminant containment in the cell, and appropriate contingency plans would be in place to rapidly address cell failure or contaminant release to the environment.

Potential impacts to local biota — primarily disturbance from excavation, construction, and disposal activities — would be temporary, and good engineering practices and appropriate mitigative measures would minimize the likelihood of short-term adverse impacts during these activities. Because of the absence of listed and C2 species from the chemical plant area and affected off-site locations, few if any short-term impacts are expected to these biota from the remedial action activities. The distance from the chemical plant area to the nearest known bald eagle winter roost site would preclude individuals at that location from being adversely affected by activities at the site.

Remedial activities under Alternative 6a would result in the temporary loss of about 38 ha (94 acres) of habitat and the permanent loss of about 17 ha (42 acres) of habitat. None of these areas provide suitable or designated critical habitat for listed species, and no impacts to listed or C2 species from this habitat disturbance are expected. Excavation activities at the potential borrow area off-site could disturb the loggerhead shrike (C2) and Bachman's sparrow (C2) and could result in the permanent loss of potential nesting and foraging habitat for these species.

I.8.3 Alternative 7a

Potential impacts to local biota under Alternative 7a are expected to be the same as those identified for Alternative 6a, and no impacts are anticipated to listed or C2 species. Potential exposure of listed and C2 species would be reduced because contaminated media would be removed, the highly contaminated material would be vitrified, and all contaminated materials would be isolated from the environment in an engineered disposal cell. In addition, the vitrification process would destroy some of the contaminants, thereby reducing the toxicity of the treated material. A program would be established to monitor contaminant containment in the cell, and appropriate contingency plans would be in place to rapidly address any cell failure or contaminant release to the environment.

Potential impacts to local biota — primarily disturbance from excavation, construction, and disposal activities — would be temporary, and good engineering practices and appropriate mitigative measures would minimize the likelihood of short-term adverse impacts during these activities. Potential impacts from exposure to off gas released during the vitrification process would be minimized through the use of an off-gas treatment system, including HEPA filters. Because no listed or C2 species occur at the chemical plant area and affected off-site locations, few if any short-term impacts are expected to these biota from the remedial action activities. Also, no disturbance to the bald eagle winter roost located on Howell Island is expected.

Remedial activities under this alternative would result in the temporary loss of about 38 ha (94 acres) of wildlife habitat, and the permanent loss of about 17 ha (42 acres) of habitat. None of these area provide suitable or designated critical habitat for listed species, and no impacts to listed or C2 species from this habitat disturbance are expected. Excavation activities at the potential borrow area off-site could disturb the loggerhead shrike (C2) and Bachman's sparrow (C2) and could result in the permanent loss of potential nesting and foraging habitat for these species.

I.8.4 Alternative 7b

Potential impacts to local biota for Alternative 7b are expected to be identical to those identified for Alternative 7a, and no impacts are anticipated to listed or C2 species. Potential impacts to local biota — primarily disturbance from excavation, construction, and disposal activities — would be temporary, and good engineering practices and appropriate mitigative measures would minimize the likelihood of short-term adverse impacts during these activities. Potential impacts from exposure to off gas released during the vitrification process would be minimized through the use of an off-gas treatment system, including HEPA filters. Because no listed or C2 species occur at the chemical plant area and affected off-site locations, few if any short-term impacts are expected to these biota from the remedial action activities. Also, no disturbance to the bald eagle winter roost located on Howell Island is expected, and no listed or C2 species occur in the area of the Wentzville rail siding.

Remedial activities under Alternative 7b would result in the temporary loss of about 55 ha (136 acres) of wildlife habitat in the Weldon Spring area. No suitable or designated critical habitat for listed species occurs in these areas, and no impacts to listed or C2 species from this habitat disturbance are expected. Excavation activities at the potential borrow area off-site could disturb the loggerhead shrike (C2) and Bachman's sparrow (C2) and could result in the permanent loss of potential nesting and foraging habitat for these species.

No impacts to the bald eagle or peregrine falcon are anticipated from the construction and operation of a disposal cell at the Envirocare facility. Bald eagle roost areas and peregrine falcon hack sites are distant enough that these species should not be affected by activities at the Envirocare facility. Construction of the disposal cell would result in the permanent loss of about 17 ha (42 acres) of semidesert shrubland and could eliminate some potential foraging habitat. Current activities associated with the facility likely preclude use of the potential disposal cell area by either of these species.

A program would be in place to monitor the integrity of cell containment, and appropriate contingency plans would be in place to rapidly address cell failure or contaminant release to the environment. The impacts from accidental releases to the environment during transport would be minimized because the more highly contaminated material would be vitrified and contaminant mobility from the vitrified product is extremely limited. In addition, a Union Pacific Railroad hazardous response team would be informed of all rail transport of contaminated materials to the Envirocare facility, and this team would respond immediately to any accidental spills that might occur during transport.

I.8.5 Alternative 7c

Potential impacts to local biota for Alternative 7c are expected to be identical to those identified for Alternative 7b, and no impacts are anticipated to listed or C2 species. Potential impacts to local biota from excavation, construction, and disposal activities would be short term, and good engineering practices and appropriate mitigative measures would minimize the likelihood of adverse impacts during these activities. Potential impacts from exposure to off-gas

releases during the vitrification process would be minimized through the use of an off-gas treatment system, including HEPA filters. No disturbance to the bald eagle winter roost located on Howell Island is expected, and no listed or C2 species occur in the area of the Wentzville rail siding.

Remedial activities under this alternative would result in the temporary loss of about 55 ha (136 acres) of wildlife habitat in the Weldon Spring area. No suitable or designated critical habitat for listed species occurs in these areas, and no impacts to listed or C2 species from this habitat disturbance are expected. Excavation activities at the potential borrow area off-site could disturb the loggerhead shrike (C2) and Bachman's sparrow (C2) and could result in the permanent loss of potential nesting and foraging habitat for these species.

Construction and maintenance of a disposal cell at the 200-West Area of the Hanford facility would have little effect on the listed and C2 species in the area because (1) construction activities would be short term; (2) except for the loggerhead shrike (C2), no listed or C2 species are known from the 200-West Area; (3) little or no suitable habitat for listed or C2 species is present at this location; and (4) the treated and untreated materials would be isolated from the environment in an engineered disposal cell. The loggerhead shrike occurs in the area and could be temporarily disturbed during construction and disposal activities. Construction of the disposal cell could eliminate about 17 ha (42 acres) of potential foraging and nesting habitat for this species, but loss of this area is not expected to result in a significant impact to this species.

A program would be in place to monitor the integrity of waste containment in the cell, and appropriate contingency plans would be in place to rapidly address cell failure or contaminant release to the environment. Accidental releases to the environment would be minimized.

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APPENDIX J:

LETTERS OF CONSULTATION

MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS:
P.O. Box 180
Jefferson City, Missouri 65102-0180

STREET LOCATION:
2901 West Truman Boulevard
Jefferson City, Missouri

Telephone: 314/751-4115
JERRY J. PRESLEY, Director

August 24, 1988

Dr. Ihor Hlohowskyj
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Dear Dr. Hlohowskyj:

In response to your recent request for species information in the Weldon Spring-St. Charles County area, I have provided copies of available data. The information is not in a format that allows us to provide separate lists for Weldon Spring Chemical Plant and Quarry Site, Weldon Spring Wildlife Area, Busch Wildlife Area, Howell Island Wildlife Area, St. Charles County and St. Louis County.

Hopefully, these lists will provide you with enough information to complete your environmental assessment.

Sincerely,

Dan F. Dickneite

DAN F. DICKNEITE
ENVIRONMENTAL ADMINISTRATOR

Enclosure

COMMISSION

JEFF CHURAN
Chillicothe

JAY HENGES
Earth City

JOHN POWELL
Rolla

RICHARD REED
East Prairie

MISSOURI DEPARTMENT OF CONSERVATION

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Jefferson City, Missouri 65102-0180

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Telephone: 314/751-4115
JERRY J. PRESLEY, Director

September 8, 1988

Mr. Ihor Hlohowskyj
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439

Dear Dr. Hlohowskyj:

Enclosed is a printout from our Heritage data base on rare and endangered plants and animals, and high quality natural communities. This listing includes plants, although I notice there aren't many plant records in St. Charles County.

The absence of occurrences of sensitive species and communities does not mean that they do not occur within the area, merely that no other information is stored in the Heritage database at this time.

The printout is self explanatory, with the following exceptions:

Precision:	S = location known exactly
	N = location precise to within 1.5 mi.
	G = location precise to within 5.0 mi.
Fed Status:	C2 = federal candidate for listing as a threatened or endangered species
	C3C = former federal candidate species
	LT = listed as a federally threatened species
	LE = listed as a federally endangered species
State Status:	WL = watchlisted
	SU = status undetermined
	R = rare
	E = endangered
	PE = possibly extirpated.

I am also enclosing a copy of our rare and endangered species checklist and Rare and Endangered Species of Missouri. If you need any further information, please to not hesitate to contact Mike Sweat or me.

Sincerely,

Eleanor P. Gaines

Eleanor P. Gaines
Data Manager

COMMISSION

JEFF CHURAN, Chillicothe
JAY HENGES, Earth City
JOHN TOWELL, Rolla
RICHARD REED, East Prairie

MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS
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Jefferson City, Missouri 65102-0180

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Jefferson City, Missouri

Telephone: 314/751-4115
JERRY J. PRESLEY, Director

March 19, 1990

Ms. Debra Reinhardt
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Dear Ms. Reinhardt:

In response to your February 6 letter to Director Presley, enclosed is information on the rare and endangered species and high quality natural communities of the Weldon Spring area. My staff have plotted the exact location of all sensitive species and communities that occur within a 10-mile radius of the Weldon Spring/Busch Wildlife Area on seven topographic maps. We have also included the Element Occurrence Record for each of these species/communities, which gives more information on each feature. Please note that the hand-written number in the upper right corner of each Element Occurrence Record corresponds to the feature's location on the topographic maps.

Supplemental information includes a data field dictionary to aid your interpretation of the Element Occurrence Records and forest cover maps for St. Charles County, as you requested.

I suggest the you contact Ms. Lisa DeBruyckere, Missouri Department of Conservation Wildlife District Supervisor, for information on important wildlife habitat in the Weldon Spring area. Ms. DeBruyckere can be contacted by calling (314)441-4554.

As I indicated above, the current search includes all species/communities that occur within a 10-mile radius of the Weldon Spring area. Please contact Holly Wheeler, (314)751-4115 (ext: 310) if you have any questions about the enclosed information.

Sincerely,

Bill Dieffenbach
Asst. Environmental Administrator

Enclosures

COMMISSION

JERRY P. COMBS, Bennett
ANDY DALTON, Springfield
JAY HENGES, St. Louis
JOHN POWELL, Rolla

MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS
P.O. Box 180
Jefferson City, Missouri 65102-0180

STREET LOCATION
2901 West Truman Boulevard
Jefferson City, Missouri

Telephone: 314/751-4115
JERRY J. PRESLEY, Director

August 9, 1991

Dr. Ihor Hlohowskyj
Argonne National Laboratory
9700 South Cass Avenue, Building 900
Argonne, Illinois 60439

Re: Natural Features Review
Wentzville, MO

Dear Dr. Hlohowskyj:

Thank you for your letter of August 1, 1991 regarding threatened and endangered species within the proposed project area.

Department staff examined map and computer files for federal and state threatened and endangered species and determined that no sensitive species or communities are known to occur on the immediate site or surrounding area. The lack of records, however, does not mean that such species or communities do not exist on this tract of land. Only an on-site inspection could verify their absence or existence.

Thank you for the opportunity to review and comment.

Sincerely,

for DAN F. DICKNEITE
PLANNING DIVISION CHIEF

COMMISSION

JERRY P. COMBS, Kennett
ANDY DALTON, Springfield
JAY HENGES, St. Louis
JOHN POWELL, Rolla

MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS
P.O. Box 180
Jefferson City, Missouri 65102-0180

STREET LOCATION
2901 West Truman Boulevard
Jefferson City, Missouri

Telephone: 314/751-4115
JERRY J. PRESLEY, Director

November 26, 1991

Mr. James R. Powers
MK-Ferguson Company
7295 Highway 94 South
St. Charles, MO 63303

Dear Mr. Powers:

Our data manager, Holly Wheeler, recently received your request for a current list rare and endangered flora and fauna for St. Charles and St. Louis counties. Attached please find the list as you requested.

In addition, you asked for more specific location information for the sturgeon chub and the sicklefin chub in the Missouri River. The following information reflects site specific information for this species:

> Sicklefin chub, Macrohybopsis meeki, and sturgeon chub, Macrohybopsis gelida, have been reported 2.7 miles southeast of Portage Des Sioux in the Missouri River near Pelican Island in St. Charles County.
>
> The sicklefin chub has also been reported 1.0 mile north of Creve Coeur Airport in the Missouri River in St. Charles County.

Both species are candidates for federal listing as Threatened or Endangered and are state listed Rare. All occurrences were last observed in 1982.

If you require any additional information please feel free to contact me or Holly Wheeler.

Sincerely,

Dennis E. Figg
Endangered Species Coordinator

DEF/djm

Enclosure

COMMISSION

JERRY P. COMBS, Kennett
ANDY DALTON, Springfield
JAY HENGES, St. Louis
JOHN POWELL, Rolla

MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS
P.O. Box 180
Jefferson City, Missouri 65102-0180

STREET LOCATION
2901 West Truman Boulevard
Jefferson City, Missouri

Telephone: 314/751-4115
JERRY J. PRESLEY, Director

March 19, 1992

Dr. Christopher P. Dunn
Argonne National Laboratory
Building 900
9700 South Cass Avenue
Argonne, Illinois 60439

Dear Dr. Dunn:

In response to your February 28, 1992 letter requesting information regarding the Weldon Spring Chemical Plant, we queried our Heritage Database. The Heritage Database contains only known sensitive species and habitat information, not complete lists of large groups of animals. The enclosed list contains all known sensitive species and habitats in St. Charles County. I believe species lists generated by Argonne Laboratory and other Department of Energy or Corps of Engineers contractors should be available from those agencies.

I hope this responds to at least part of your needs. If necessary, we could generate county lists.

Sincerely,

Dan F. Dickneite

DAN F. DICKNEITE
PLANNING DIVISION CHIEF

Enclosure

COMMISSION

JERRY P. COMBS, Kennett
ANDY DALTON, Springfield
JAY HENGES, St. Louis
JOHN POWELL, Rolla

SENSITIVE SPECIES AND HIGH-QUALITY NATURAL COMMUNITIES KNOWN FROM ST. CHARLES COUNTY
PRINTOUT OF THE NATURAL HERITAGE DATABASE
10 MAR 1992
1

SCIENTIFIC NAME	COMMON NAME	FED.	STATE	LAST OBSERVED	TOWN/RANGE	SEC		PRECISION*
ACCIPITER COOPERII	COOPER'S HAWK		R	1986-00-00	045N002E	03	NE4NW4NW4	S
ACCIPITER COOPERII	COOPER'S HAWK		R	1985-00-00	045N003E	05	NW4NE4SW4	S
***								
AMEIURUS NEBULOSUS	BROWN BULLHEAD		R	1944-09-26	048N006E	13		S
***								
ARDEA HERODIAS	GREAT BLUE HERON ROOKERY		-	1983-04-28	048N005E	01		H
***								
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN		E	1989-07-20	048N007E	26	SE4NW4	S
***								
ELAPHE VULPINA VULPINA	WESTERN FOX SNAKE		E	1990-06-00	048N005E	26		S
ELAPHE VULPINA VULPINA	WESTERN FOX SNAKE		E		047N004E	09		G
ELAPHE VULPINA VULPINA	WESTERN FOX SNAKE		E		047N005E	01		G
ELAPHE VULPINA VULPINA	WESTERN FOX SNAKE		E		047N005E	18	ALSO WS 7110009	H
ELAPHE VULPINA VULPINA	WESTERN FOX SNAKE		E	1990-06-04	048N003E	30	S2	S
***								
GALLINULA CHLOROPUS	COMMON MOORHEN		R	1989-07-20	048N005E	26	NW4	S
***								
LEPISOSTEUS SPATULA	ALLIGATOR GAR		R		047N004E	03		S
LEPISOSTEUS SPATULA	ALLIGATOR GAR		R	1944-09-26	048N006E	13		S
***								
MACRHYBOPSIS GELIDA	STURGEON CHUB	C2	R	1969-09-12	047N007E	08		S
MACRHYBOPSIS GELIDA	STURGEON CHUB	C2	R	1963-09-26	045N003E	02	ALONG SEC 35	S
MACRHYBOPSIS GELIDA	STURGEON CHUB	C2	R	1982-10-05	048N006E	34	NE4	S
***								
MACRHYBOPSIS MEEKI	SICKLEFIN CHUB	C2	R	1969-09-12	047N007E	08		S
MACRHYBOPSIS MEEKI	SICKLEFIN CHUB	C2	R	1983-09-25	047N007E	05		S
MACRHYBOPSIS MEEKI	SICKLEFIN CHUB	C2	R	1944-00-00	047N006E	18		S
MACRHYBOPSIS MEEKI	SICKLEFIN CHUB	C2	R	1963-09-26	045N003E	02	ALONG SEC	S

*PRECISION
S = SPECIES/COMMUNITY IS KNOWN FROM LISTED LOCATION
H = SPECIES/COMMUNITY IS KNOWN TO OCCUR WITHIN 1.5 MILE RADIUS OF LISTED LOCATION
G = SPECIES/COMMUNITY IS KNOWN TO OCCUR WITHIN 5.0 MILE RADIUS OF LISTED LOCATION

SENSITIVE SPECIES AND HIGH-QUALITY NATURAL COMMUNITIES KNOWN FROM ST. CHARLES COUNTY
PRINTOUT OF THE NATURAL HERITAGE DATABASE
10 MAR 1992
2

SCIENTIFIC NAME	COMMON NAME	FED.	STATE	LAST OBSERVED	TOWN/RANGE	SEC		PRECISION*
						35		
MACROMBOPSIS MEEKI	SICKLEFIN CHUB	C2	R	1982-10-05	046N004E	0		S
MACROMBOPSIS MEEKI	SICKLEFIN CHUB	C2	R	1982-10-05	048N006E	34	ME4	S
***								
RALLUS ELEGANS	KING RAIL		E	1989-07-20	048N005E	26	NW4	S
***								
RANA SYLVATICA	WOOD FROG		R	1980-03-19	046N002E	25	& OTHER SECTIONS	S
***								
SCAPHIRHYNCHUS ALBUS	PALLID STURGEON	LE	E	1944-08-00	047N008E	08		S
SCAPHIRHYNCHUS ALBUS	PALLID STURGEON	LE	E	1969-09-12	047N007E			S
***								
SISTRURUS CATENATUS CATENATUS	EASTERN MASSASAUGA	C2	E	1961-04-14	047N005E	0		G
SISTRURUS CATENATUS CATENATUS	EASTERN MASSASAUGA	C2	E		047N003E	01		H
SISTRURUS CATENATUS CATENATUS	EASTERN MASSASAUGA	C2	E		047N004E	18	ALSO SEC. 7	S
***								
TYTO ALBA	BARN OWL		R	1987-04-17	048N005E	24	S2	S
TYTO ALBA	BARN OWL		R	1989-04-00	048N005E	25	ME&NW4	S
TYTO ALBA	BARN OWL		R	1989-07-20	048N005E	25	NW4	S
***								
BERGIA TEXANA	BERGIA		R	1991-08-24	048N007E	33		S
BERGIA TEXANA	BERGIA		R	1990-09-10	048N007E	28		S
***								
BOLTONIA DECURRENS	DECURRENT FALSE ASTER	LT	E	1991-08-24	048N007E	33		S
BOLTONIA DECURRENS	DECURRENT FALSE ASTER	LT	E	1991-06-18	048N007E	28		S
BOLTONIA DECURRENS	DECURRENT FALSE ASTER	LT	E	1990-11-13	048N005E	24	NW&NW&E4	S
***								
CHELONE OBLIQUA VAR SPECIOSA	ROSE TURTLEHEAD	3C	E	1980-09-23	049N005E	33		H

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SENSITIVE SPECIES AND HIGH-QUALITY NATURAL COMMUNITIES KNOWN FROM ST. CHARLES COUNTY
PRINTOUT OF THE NATURAL HERITAGE DATABASE
10 MAR 1992
3

SCIENTIFIC NAME	COMMON NAME	FED.	STATE	LAST OBSERVED	TOWN/RANGE	SEC		PRECISION*
LEMNA TRISULCA	STAR DUCKWEED		R	1986-07-16	048N003E	32	NWSW	S
LYTHRUM SALICARIA	PURPLE LOOSESTRIFE			1988-08-25	047N002E	33	SW	S
LYTHRUM SALICARIA	PURPLE LOOSESTRIFE			1988-08-25	047N003E	27	SW	S
LYTHRUM SALICARIA	PURPLE LOOSESTRIFE			1988-08-25	047N003E	34	NW	S
LYTHRUM SALICARIA	PURPLE LOOSESTRIFE			1988-08-25	047N003E	26	NWSE4	S
PELTANDRA VIRGINICA	ARROW ARUM		R	1928-06-26	047N003E	0		G
SPIRANTHES OVALIS	OVAL LADIES' TRESSES		R	1845-09-00	047N007E	0		G
CHERT SAVANNA			R	1985-08-26	045N002E	11	NESWNW	S
DRY CHERT FOREST			-	1985-08-26	045N002E	11	NESWNW	S
DRY-MESIC CHERT FOREST			-	1985-09-04	046N003E	05	ALSO SEC 4	S
FRESHWATER MARSH			R	1986-03-00	048N003E	32	NW SEC 31	S
MESIC FOREST			-	1985-09-04	046N003E	05	ALSO SEC 4	S
[illegible] SWAMP			R	1986-09-03	048N006E	05	& SEC 4	S
[illegible] SWAMP			R	1986-06-12	048N003E	32	& 047N003E SEC 5	S

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SENSITIVE SPECIES AND HIGH-QUALITY NATURAL COMMUNITIES KNOWN FROM ST. CHARLES COUNTY
PRINTOUT OF THE NATURAL HERITAGE DATABASE
10 MAR 1992
4

SCIENTIFIC NAME	COMMON NAME	FED.	STATE	LAST OBSERVED	TOWN/RANGE	SEC		PRECISION*
WET PRAIRIE			E	1986-06-12	048N003E	32	& 047N003E SEC 5	S
WET PRAIRIE			E	1986-04-18	047N003E	01	W2, SEC2, E2	S
***								
WET-MESIC BOTTOMLAND FOREST			E	1986-09-03	048N006E	06		S
***								
WET-MESIC PRAIRIE			E	1986-04-18	047N003E	01	E2W2	S
***								
HALIAEETUS LEUCOCEPHALUS NEST ROOST	BALD EAGLE NIGHT ROOST	LELT	E	1985-01-11	045N003E	08		H
***								

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MISSOURI DEPARTMENT OF CONSERVATION

MAILING ADDRESS
P.O. Box 180
Jefferson City, Missouri 65102-0180

STREET LOCATION
2901 West Truman Boulevard
Jefferson City, Missouri

Telephone: 314 751-4115
JERRY J. PRESLEY, Director

July 27, 1992

Mr. Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Program
7295 Highway 94 South
St. Charles, MO 63304

Dear Mr. McCracken:

As a follow-up to discussions at the June 11, 1992 meeting concerning remedial actions at the Weldon Spring Site, I inquired of our Fisheries and Wildlife Divisions regarding planned Weldon Spring and Busch Wildlife Area renovation during the next several years. They provided me with the following information that indicates our priorities:

Lake	Size (acres)	Priority	FY	Comments
#4	2.0	1	1994	-
#10	3.5	2	1994	-
#36	15.5	1	1995	Contaminated Sediment
#19	3.2	2	1995	-
Femme Osage Slough	15.7	1	1996	Contaminated Sediment
#5	3.4	2	1996	-
#35	62.5	1	1997	Contaminated Sediment and Leaks
#26	12.0	1	1998	-
#21	5.7	2	1998	-
#8	15.8	1	1999	Leaks
#16	8.8	2	1999	-

COMMISSION

JERRY P. COMBS, Kennett
ANDY DALTON, Springfield
JAY HENGES, St. Louis
JOHN POWELL, Rolla

While the list reflects our current thinking, changes could be made to accommodate activities involved with site remediation. Also, if a priority project cannot be completed in the scheduled year, the project would bump down the time line.

I hope this list will be of assistance as you and your staff plan for the remediation of the Weldon Spring site. If you have questions or comments, please call me.

Sincerely,

WILLIAM H. DIEFFENBACH
ASST. PLANNING DIVISION CHIEF

WHD:jct

JOHN ASHCROFT
Governor

FREDERICK A. BRUNNER
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation, and Historic Preservation

DIVISION OF PARKS, RECREATION, AND HISTORIC PRESERVATION
P.O. Box 176
Jefferson City, MO 65102
314-751-2479

November 3, 1986

R. R. Nelson, Project Manager
Weldon Spring Site Remedial Action
Project
Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37831

RE: Proposed Radiologically Contaminated Remedial Action Project (DOE), Weldon Springs Ordinance Works, St. Charles County, Missouri

Dear Mr. Nelson:

In response to your letter dated 6 October 1986 concerning the above referenced subject, the Missouri Historic Preservation Program has reviewed the information provided by Mr. James Coyne, PEER Consultants, during our 26 September 1986 meeting, relative to the proposed remedial action for radiologically contaminated areas and it is the opinion of this office that most of the areas directly involved have either been previously disturbed by various construction related activities or exhibit a low potential for the occurrence of archaeological properties. In viewing these factors, combined with the potential health risk associated with conducting archaeological investigation in a radiologically contaminated area, it is the opinion of this office that an archaeological survey of contaminated areas is not warranted.

However, in regard to any area associated with the proposed remedial action which are uncontaminated or have not been subject to substantial previous disturbance, archaeological investigation would be required. This would include any borrow areas, haul road, and land clearance action associated with the proposed undertaking.

Relative to the area included within the Weldon Springs chemical plant, it is the opinion of this office that the area was significantly disturbed during plant construction and any archaeological resources present would have been severely damaged or destroyed. Therefore, further investigation would not be warranted. It is also the opinion of this office that the plant facility itself is not eligible for inclusion in the National Register of Historic Places.

If I can be of further assistance, please write or call (314)751-7958.

Sincerely,

DIVISION OF PARKS, RECREATION,
AND HISTORIC PRESERVATION

Michael S. Weichman
Chief, Review and Compliance

MSW:jh

JOHN ASHCROFT
Governor

G. TRACY MEHAN III
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF PARKS, RECREATION, AND HISTORIC PRESERVATION
P.O. Box 176
Jefferson City, MO 65102
314-751-2479

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation
and Historic Preservation

January 7, 1992

Mr. Stephen H. McCracken
Weldon Spring Site
Remedial Action Project Office
7295 Highway 94 South
St. Charles, Missouri 63304

RE: Potential Archaeological Survey -- Proposed off-site Borrow Source

Dear Mr. McCracken:

In response to your letter dated 24 December 1991, the Historic Preservation Program has examined our records and have found that the proposed study area has been partially surveyed for cultural resources. (See enclosed map.)

The study area proposed contains previously recorded archaeological sites 23SC349 and 23SC350; site 23SC351 may lie partly in the study area; and site 23SC352 is in close proximity.

If the proposed borrow area can be relocated in a previously surveyed area and sites 23SC359, 23SC350 and 23SC351 can be avoided, we would have no objection to initiation of project activities. However, if this is not possible, a cultural resources survey of the remaining area will be needed.

If I can be of further assistance, please write or call 751-7860.

Sincerely,

HISTORIC PRESERVATION PROGRAM

Chris Hansman
Acting Senior Archaeologist

mc

Enclosure

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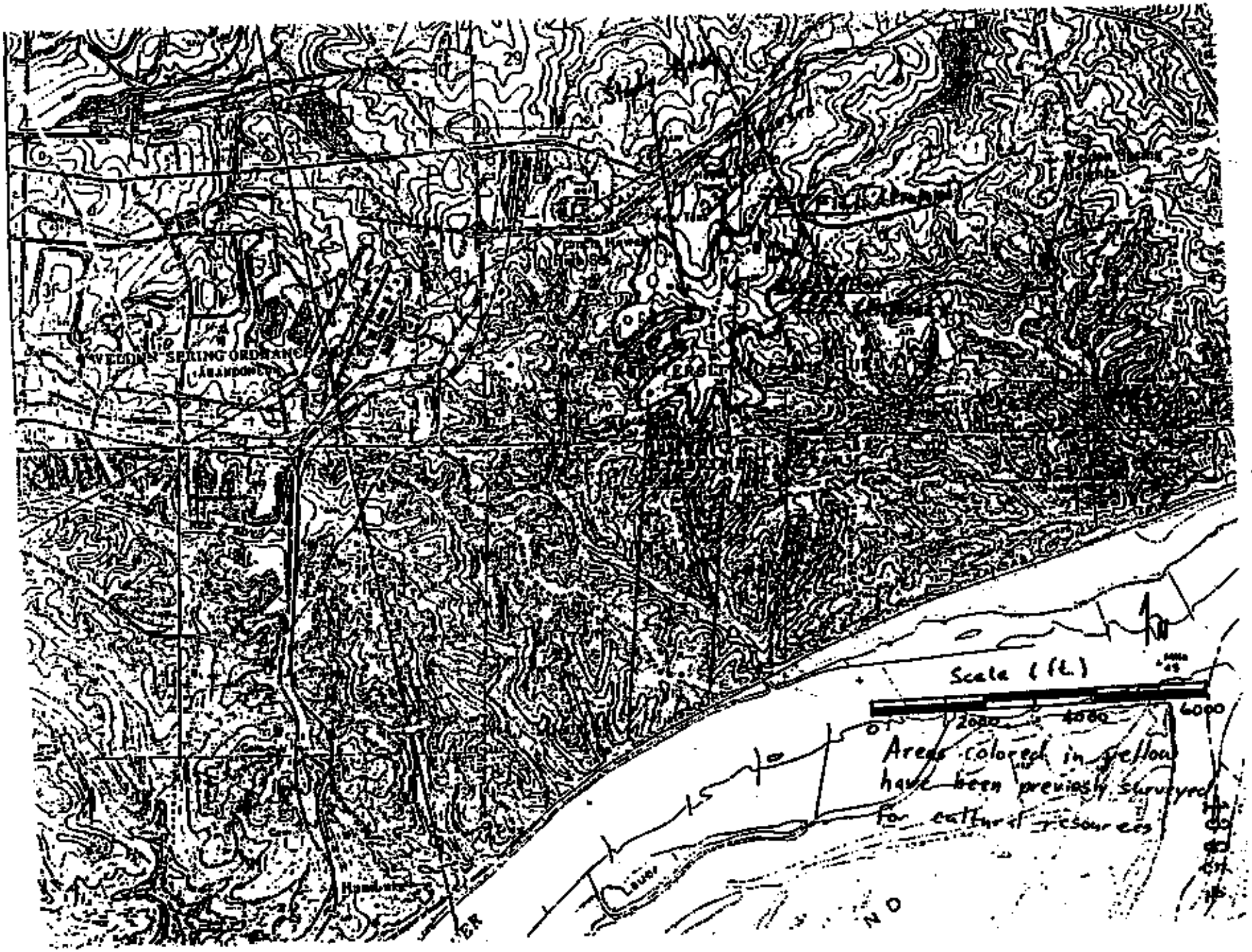
Scale (ft.)
0
2000
4000
6000
Areas colored in yellow
have been previously surveyed
for cultural resources

JOHN ASHCROFT
Governor

G. TRACY MEHAN III
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation, and Historic Preservation

DIVISION OF PARKS, RECREATION, AND HISTORIC PRESERVATION
P.O. Box 176
Jefferson City, MO 65102
314-751-2479

February 18, 1992

Mr. Stephen H. McCracken, Project Manager
Department of Energy, Oak Ridge Operations
Weldon Spring Site Remedial Action Project
7295 Highway 94 South
St. Charles, Missouri 63303

Re: Proposed Borrow Area (DOE), Weldon Spring Site Remedial Action Project, St. Charles County, Missouri

Dear Mr. McCracken:

The Historic Preservation Program has reviewed the February 1992 report entitled "A Phase I Survey and Evaluation of a Proposed Borrow Site for the Weldon Spring Site Remedial Action Project, St. Charles County, Missouri," by Gary Rex Walters. Based on this report, it is evident an adequate cultural resource survey has been made of the project area.

We agree with the investigator's recommendations as outlined on pages 63-64 of the report. If at all possible, the proposed project should be designed to avoid archaeological sites:

23SC349,	23SC870,	23SC875,	23SC878,
23SC352,	23SC871,	23SC876,	and
23SC869,	23SC872,	23SC877,	23SC879.

If this is not feasible, the following course of action is strongly recommended. Subsurface archaeological testing of the above mentioned sites, which are potentially eligible for inclusion in the National Register, should be initiated with the results submitted to the Missouri Historic Preservation Program and the Department of Energy (DOE) to ascertain eligibility for inclusion in the National Register of Historic Places in accordance with the procedures as set forth in Section 800.4(c) of the Advisory Council on Historic Preservation's regulation Protection of Historic Properties (36CFR Part 800).

In the event these sites are determined eligible, then the appropriate course of action as outlined in Section 800.5 of the Advisory Council on Historic Preservation's regulation should be implemented.

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Pending completion of this process, no action should be taken that would foreclose consideration of alternatives to avoid or satisfactorily mitigate any adverse effects on archaeological sites

23SC349,	23SC870,	23SC875,	23SC878,
23SC352,	23SC871,	23SC876,	and
23SC869,	23SC872,	23SC877,	23SC879.

If I can be of further assistance, please write or call 314/751-7958.

Sincerely,

HISTORIC PRESERVATION PROGRAM

Chris Hansman
Acting Senior Archaeologist

mc

c: David Dutton
Gary Rex Walters

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
700 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-2896

REPLY TO ATTENTION OF:

December 6, 1990

Permit Evaluation and
Enforcement Section
(SC, MO, NPR)

Dr. Ihor Hlohowskyj
Argonne National Laboratory
Environmental Assessment and
Information Science Division
9700 South Cass Avenue, Building 301
Argonne, Illinois 60439

Dear Dr. Hlohowskyj:

This letter is in reply to your November 5, 1990, letter requesting a Department of the Army (DA) permit determination for remediation of containment ponds at the Weldon Spring National Priority List (NPL) site in St. Charles County, Missouri.

In accordance with our regulatory guidance, a DA permit is not required for Comprehensive Environmental Response Compensation and Liability Act (CERCLA) activities within the NPL boundary.

Although a DA permit is not required this does not preclude the possibility that other Federal, state and/or local permits may be required, and you should satisfy yourself in this regard.

If you have any questions concerning this matter, please feel free to write me or to call Mr. Jim Scott at 816-426-5500.

Sincerely,

M. D. Jewett
Chief, Regulatory Branch
Operations Division

Copies Furnished:

Mr. Robert E. Hlavacek
Project Director
MK-Ferguson Company
7295 Highway 94 South
St. Charles, Missouri 63303

Missouri Department of
Natural Resources

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

April 10, 1991

Ms. Sheila Huff
Office of the Secretary
U.S. Department of Interior
230 S. Dearborn, Suite 3422
Chicago, Illinois 60604

Dear Ms. Huff:

NOTIFICATION TO NATURAL RESOURCE TRUSTEES, 40 CFR 300.135(j)
SUBPART G - TRUSTEES FOR NATURAL RESOURCES

As a trustee for natural resources located on, over, or under land administered by the United States, this letter is to officially notify you as a co-trustee that the Department of Energy (DOE) is planning to remediate the Weldon Spring Site. The remediation work will be performed in accordance with decisions reached under NEPA and CERCLA.

Discharges or releases of hazardous substances have occurred. The WSSRAP is being conducted to eliminate potential hazards to the public and the environment that are associated with a uranium processing facility that operated from 1957 to 1966. The site consists of four large waste pits, an inactive Chemical Plant, and a quarry that has been filled with contaminated debris. Also, included are several small areas outside the Chemical Plant and the quarry called vicinity properties contaminated as a result of activities associated with previous uranium processing.

The WSSRAP has been listed on the Environmental Protection Agencies National Priorities List. As such, the EPA has final approval authority on cleanup, treatment and disposal decisions. To date, a number of interim actions have been or are being carried out to reduce offsite discharges, improve site safety and to better stabilize the site. Enclosed is a list of these activities. For each of the activities listed, a decision making document(s) was prepared and agreed upon by the State of Missouri and EPA. The most significant decision to date was finalized in March, 1991 and involves the removal transport and temporary storage of waste from the quarry. Two other important decisions that are now in various stages of engineering and construction involve treatment and discharge of contaminated surface waters at the quarry and chemical plant. Any of the listed documents can be made available to you at your request.

A copy of the Work Plan for the Remedial Investigation/ Feasibility Study-Environmental Impact Statement for the Weldon Spring Site, August 1988 is enclosed for your use. The Work Plan was developed to show how DOE will carry out environmental compliance activities required to support decisions under both NEPA and CERCLA.

Upcoming decisions in 1991 and 1992 will establish requirements for demolition of structures at the chemical plant and requirements for final cleanup, treatment and disposal of all radiological and chemical waste. We will put your office on distribution for documents related to these decisions.

If you have any questions please give me a call. In order to assist you in carrying out your responsibilities as a Natural Resource Trustee we would be pleased to meet with you and provide a comprehensive briefing.

Sincerely,

Jerry S. VanFossen

for Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc w/o enclosure:
Bill Adams, EW-90
Peter Gross, SE-31
W.E. Murphie, EM-423
Jim Powers, PMC
Margaret MacDonell, ANL

Removal and Remedial Actions

	Action	Document	
1.	Electrical Power Line and Pole Removal	EE/CA	11/87
2.	Ash Pond Isolation Dike	EE/CA	06/88
3.	Army Vicinity Property	EE/CA	11/87
4.	Overhead Piping/Asbestos Removal	EE/CA	11/87
5.	Disposal of Containerized Chemicals	EE/CA	11/87
6.	PCB Transformer Removal	EE/CA	11/87
7.	Debris Consolidation	EE/CA	11/87
8.	Dismantling of Building 409	EE/CA	11/87
9.	Dismantling of Building 401	EE/CA	11/87
10.	Dismantling of Non-Process Buildings	EE/CA	08/90
11.	Dismantling of Process Buildings	EE/CA	in draft
12.	Site Water Treatment Plant	EE/CA	07/90
13.	Quarry Water Treatment Plant	EE/CA	01/89
14.	Quarry Bulk Waste Removal	ROD	03/91

EE/CA - Engineering Evaluation/Cost Analysis
ROD - Record of Decision

Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

April 10, 1991

Mr. Tracy Mehan, III
Director,
Missouri Department of Natural Resources
Post Office Box 176
Jefferson City, Missouri 65102

Dear Mr. Mehan:

**NOTIFICATION TO NATURAL RESOURCE TRUSTEES, 40 CFR 300.135(j)
SUBPART G - TRUSTEES FOR NATURAL RESOURCES**

As a trustee for natural resources located on, over, or under land administered by the United States, this letter is to officially notify you as a co-trustee that the Department of Energy (DOE) is planning to remediate the Weldon Spring Site. The remediation work will be performed in accordance with decisions reached under NEPA and CERCLA.

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Upcoming decisions in 1991 and 1992 will establish requirements for demolition of structures at the chemical plant and requirements for final cleanup, treatment and disposal of all radiological and chemical waste. Mr. Dave Bedan has been involved in development of these documents.

If you have any questions please give me a call. In order to assist you in carrying out your responsibilities as a Natural Resource Trustee we would be pleased to meet with you and provide a comprehensive briefing.

Sincerely,

Jerry L. Van Fossen

for Stephen H. McCracken
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosure:
As stated

cc w/o enclosure:
Bill Adams, EW-90
Peter Gross, SE-31
W.E. Murphie, EM-423
Jim Powers, PMC
Margaret MacDonell, ANL

Removal and Remedial Actions

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3.	Army Vicinity Property	EE/CA	11/87
4.	Overhead Piping/Asbestos Removal	EE/CA	11/87
5.	Disposal of Containerized Chemicals	EE/CA	11/87
6.	PCB Transformer Removal	EE/CA	11/87
7.	Debris Consolidation	EE/CA	11/87
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9.	Dismantling of Building 401	EE/CA	11/87
10.	Dismantling of Non-Process Buildings	EE/CA	08/90
11.	Dismantling of Process Buildings	EE/CA	in draft
12.	Site Water Treatment Plant	EE/CA	07/90
13.	Quarry Water Treatment Plant	EE/CA	01/89
14.	Quarry Bulk Waste Removal	ROD	03/91

EE/CA - Engineering Evaluation/Cost Analysis
ROD - Record of Decision

United States Department of the Interior

FISH AND WILDLIFE SERVICE
COLUMBIA FIELD OFFICE (ES)
P.O. Box 1508
Columbia, Missouri 65205

IN REPLY REFER TO:

December 22, 1988

Ihor Hlohowskyi, Ph.D.
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

Dear Dr. Hlohowskyi:

This is in reference to your letter and attached map of December 6, 1988 requesting Threatened and Endangered Species information for Federally listed species.

Endangered Species Comments

Under Section 7(c) of the Endangered Species Act, Federal agencies are required to obtain from the Fish and Wildlife Service information concerning any species, listed or proposed to be listed, which may be present in the area of a proposed action. Therefore, we are providing you with the following list of species which may be present in the concerned area:

Endangered

Bald eagle (Haliaeetus leucocephalus)

Under 7(c) of the Endangered Species Act of 1973, as amended, the Federal agency responsible for actions authorized, funded, or carried out in the furtherance of a construction project that significantly affects the quality of the human environment, is required to conduct a biological assessment. The purpose of the assessment is to identify listed or proposed species likely to be adversely affected by their action and to assist the Federal agency in making a decision as to whether they should initiate consultation.

If you have any questions regarding this response or if we can be of any further assistance, please contact Mr. Tom Nash, Columbia Field Office, P. O. Box 1506, Columbia, Missouri 65205, (314)875-5374 or (FTS)276-5374.

Sincerely yours,

Joe Tiager

Joe Tiager
Field Supervisor

TJN:mb:1124STWELDOB

United States Department of the Interior
Fish and Wildlife Service
Fish and Wildlife Enhancement
Columbia Field Office
608 East Cherry Street
Columbia, Missouri 65201

May 9, 1990

In Reply Refer to:
FWS/AFWE-CMFO

Argonne National Laboratory
Attn: Ihor Hlohowskyj, Ph.D.
9700 South Cass Avenue EID/301
Argonne, Illinois 60439-4836

Dear Dr. Hlohowskyj:

Our information on Threatened and Endangered species at the Weldon Spring site has not changed since our letter to you of December 22, 1988 (copy enclosed). Also enclosed for your use is a letter with enclosure to Mr. Ken Lawver of the Department of Energy. This further defines our position relating to Threatened and Endangered species.

Should you have questions concerning this response, or if we can be of any further assistance, please contact Mr. Tom Nash at the address above, or by telephone at (314)876-1911 or (FTS)276-1911.

Sincerely yours,

Acting Tom Nash
Jerry J. Brabander
Field Supervisor

Enclosures

cc: MDC; Jefferson City, MO (Attn: Dan Dickneite)
MDC; Jefferson City, MO (Attn: Dennis Figg)
MDNR; Jefferson City, MO (Attn: Charles Stiefferмann)
EPA; Kansas City, KS (Attn: Bob Barber)

TJN:tn:1124stweldod

United States Department of the Interior
Fish and Wildlife Service
Fish and Wildlife Enhancement
Columbia Field Office
608 East Cherry Street
Columbia, Missouri 65201

TAKE PRIDE IN AMERICA

In Reply Refer to:
FWS\FWE-CMFO

JUN 13 1991

Stephen H. McCracken
Project Manager
Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

Dear Mr. McCracken:

This responds to your May 15, 1991, letter requesting comments on the proposed remedial action involving the filling of four raffinate pits and two drainage ponds at the Weldon Springs site in St. Charles County, Missouri.

The remedial action will involve draining and treating the raffinate water and treating the raffinate sludge. Subsequent to pit clean-up the pits will be filled in and graded to eliminate ponding of surface water runoff.

During remediation, two drainage ponds, frog pond and ash pond, will also likely require clean-up in which case the topography in those areas will be reconfigured to eliminate these ponds.

We strongly encourage you to reconsider creating wetlands after completion of the final disposal cell. In light of the need to obtain borrow material to fill the raffinate pits, the creation of depressional wetlands could be accomplished without any significant increase in project costs. Due to the overall loss of wetlands in the State of Missouri and nation-wide, a few scattered lakes and ponds within the general vicinity does not diminish the value of wetlands nor justify their elimination. If appropriate, non-contaminated sites exist in the immediate project vicinity, we believe the creation of additional wetlands would only make the existing lakes and ponds more valuable due to increased diversity and collective magnitude. We would be glad to meet with you to discuss wetland creation strategies for the project area during remedial action planning.

Should you have questions concerning these comments and recommendations, or if we can be of any further assistance, please contact Richard Szlemp at the address above, or by telephone at (314)876-1911 or (FTS)276-1911.

Sincerely,

Jerry J. Brabander
Field Supervisor

cc: MDC; Jefferson City, MO (Attn: Dan Dicknsite)
EPA; Kansas City, KS (Attn: Kathy Mulder)
MDNR; Jefferson City, MO (Attn: Charles Stiefermann)

RRS:rs:1132\STRAFFXA

United States Department of the Interior
Fish and Wildlife Service
Fish and Wildlife Enhancement
Columbia Field Office
608 East Cherry Street
Columbia, Missouri 65201

TAKE PRIDE IN AMERICA

In Reply Refer to:
FWE/AFWE-CMFO

JUN 2 7 1991

Dr. Ihor Hlohowskyj
Argonne National Laboratory
Environmental Assessment and Information Sciences Division
9700 South Cass Avenue
Building 900
Argonne, Illinois 60439

Dear Dr. Hlohowskyj:

This responds to your letter, dated June 5, 1991, requesting the comments of the U.S. Fish and Wildlife Service (Service) on the proposed rail siding located in Wentzville, Missouri, for the temporary storage of containerized treated wastes to be transported by rail to a disposal facility.

These comments are provided as technical assistance and predevelopment consultation and do not constitute a Service report under authority of the Fish and Wildlife Coordination Act (Coordination Act) (16 U.S.C. 661 et seq.) on any required Federal environmental review or permit or license application.

We have reviewed the plans for the proposed project and offer the following comments:

1. The proposed project does not appear to impact Federal fish and wildlife management facilities. Please contact the Missouri Department of Conservation (P.O. Box 180, Jefferson City, Missouri 65102) concerning State management facilities.

2. Construction and operational activities should avoid wetlands, streams, and riparian zones to the maximum extent possible. If impact to these areas is unavoidable, a permit may be required from the U.S. Army Corps of Engineers and/or the Missouri Department of Natural Resources. If a Federal permit is required, the Service would review the application and provide recommendations.

3. No federally listed endangered or threatened species occur in the project area. However, please contact the Missouri Department of Conservation concerning State-listed endangered and threatened species.

4. Please contact the Environmental Protection Agency-Region VII (726 Minnesota Avenue, Kansas City, Kansas 66101) for information on the regulations pertinent to temporary storage of containerized treated wastes and on the transportation of these wastes.

Based upon the submitted information, we have no objection to this proposal as currently planned, provided that our recommendations are followed. However, should the plans be modified, we recommend that you reinitiate coordination with this office.

Should you have questions concerning this response, or if we can be of any further assistance, please contact Ms. Colette Charbonneau at the address above, or by telephone at (314)876-1911 or (FTS)276-1911.

Sincerely yours,

Tom Nash
Acting

Jerry J. Brabender
Field Supervisor

cc: MDC; Jefferson City, MO (Attn: Dan Dicknaite)
MDC; Jefferson City, MO (Attn: Dennis Figg)
MDNR; Jefferson City, MO (Attn: Charles Stiefermann)
EPA; Kansas City, KS (Attn: Kathy Mulder)

CSC:ec:1124/STWELDOS

United States Department of the Interior

FISH AND WILDLIFE SERVICE
FISH AND WILDLIFE ENHANCEMENT
UTAH STATE OFFICE
2078 ADMINISTRATION BUILDING
1745 WEST 1700 SOUTH
SALT LAKE CITY, UTAH 84104-5110

In Reply Refer To

(FWE)

July 2, 1991

Ihor Hlohowskyj, Ph.D.
Environmental Assessment &
Information Sciences Division
Argonne National Laboratory
9700 South Cass Avenue, Bldg 900
Argonne, Illinois 60439

Dear Mr. Hlohowskyj:

We have reviewed your letter of June 5, 1991 concerning the preparation of a Feasibility Study-Environmental Impact Statement for the U.S. Department of Energy to address remedial action activities at the Weldon Spring NPL Site near St. Louis, Missouri. One alternative would be to transport the site wastes to a commercial disposal facility located near Clive, Utah.

It appears that listed endangered and threatened species may occur in the area of influence of this action.

To comply with Section 7(c) of the Endangered Species Act of 1973, as amended, Federal agencies or their designees are required to obtain from the U.S. Fish and Wildlife Service (Service) information concerning any species or critical habitat, listed or proposed to be listed, which may be present in the area of a proposed construction project. Therefore, we are furnishing you the following list of species which may be present in the concerned area:

Listed

bald eagle	Haliaeetus leucocephalus
peregrine falcon	Falco peregrinus

Section 7(c) also requires that the Federal agency proposing a major construction activity that significantly affects the quality of the human environment to conduct and submit to the Service a biological assessment to determine the effects of the proposal on listed and proposed species and designated and proposed critical habitat. The biological assessment shall be completed within 180 days after the date on which initiated or, a time mutually agreed upon between the agency and the Service. Before physical modification/alteration of a major Federal action is begun, the assessment must be completed. If the biological assessment is not begun within 90 days, this list should be verified with us prior to initiation of the assessment. We do not feel that we can adequately assess the effects of the proposed action on listed and proposed species or critical habitat and proposed critical habitat without a complete assessment.

When conducting a biological assessment, a thorough review of the project and the potential impacts of the project on threatened and endangered species within the immediate project area, as well as the area of influence, must be made.

Specific concerns that the Service has about this project and its potential impacts on threatened and endangered species are as follows:

bald eagle

The bald eagle is a winter resident of the State of Utah. Only two active nests have been documented in the southeastern part of the state in recent times. Compared to the rest of the nation, however, Utah has one of the largest wintering populations of eagles. In the 1983 Midwinter Bald Eagle Survey sponsored by the National Wildlife Federation, Utah ranked second with a total count of 1,042. This amounted to 9 percent of the total U.S. count for that year.

One of the largest concentrations of wintering eagles in Utah occurs in Rush Valley, Tooele County. As many as 200 birds have been counted in this area. Roosting sites occur in clumps of trees on the valley floor and in protected canyon areas. The numbers of bald eagles in any one area fluctuates according to weather, food supply and time of year. It appears that peak numbers occur in January and early February. The birds begin to arrive in Utah in mid-November and leave by March to begin nesting in the northern United States and Canada. A smaller number of eagles winter in Skull Valley which is located east of the Clive site.

peregrine falcon

The Utah Division of Wildlife Resources, in cooperation with the Peregrine Fund in Boise, Idaho, has been conducting a program to reintroduce peregrines to the State of Utah. Hack towers used in the reintroduction program have been built around the Great Salt Lake for this purpose. It is hoped that by establishing a core population of falcons on the marshes around the lake that the birds will expand into historical cliff habitat along the Wasatch Front east of the lake. One hack site, constructed on the north end of the Stansbury Mountains near Timpie, Utah that was used to release young captive-raised falcons, now has a nesting pair of peregrines returning to use the box. This site is approximately 26 miles east of the Clive site. A second hack tower on Antelope Island is also being used by a pair of peregrine falcons. This tower is approximately 55 miles northeast of the Clive site.

Concerns

Our concerns for both endangered species are related to the toxicity of the chemicals that may accidentally be released into the environment and the subsequent impact to these species. These factors should be discussed as fully as possible in the environmental impact statement.

After the relevant Federal agency has reviewed the assessment, it is that agency's responsibility to determine if the proposed action "may affect" any of the listed species or critical habitats. The agency should also determine if the action is likely to jeopardize the continued existence of proposed species or result in the destruction or an adverse modification of any critical habitat proposed for such species. If the determination is "may affect" for listed species, the agency must request in writing formal consultation from the Assistant Field Supervisor, Fish and Wildlife Enhancement, at the address given above. In addition, if the agency determines that the proposed action is likely to jeopardize the continued existence of proposed species or result in the destruction of adverse modification of proposed critical habitat, it must confer with the Service. At that time, the agency should provide this office a copy of the biological assessment and any other relevant information that assisted it in reaching its conclusion.

The Service can enter into formal Section 7 consultation only with another Federal agency. State, county or any other governmental or private organizations can participate in the consultation process, help prepare information such as the biological assessment, participate in meetings, etc.

Your attention is also directed to Section 7(d) of the Endangered Species Act, as amended, which underscores the requirement that the Federal agency or the applicant shall not make any irreversible or irretrievable commitment of resources during the consultation period which, in effect, would deny the formulation or implementation of reasonable and prudent alternatives regarding their actions on any endangered or threatened species.

If we can be of further assistance, please advise us. The Service representative who will provide you with technical assistance is Robert Benton; FTS 588-4430, Commercial (801)524-4430.

Sincerely,

Clark D. Johnson
Assistant Field Supervisor

cc: Utah Division of Wildlife Resources/Springville

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Fish and Wildlife Enhancement
3704 Griffin Lane SE, Suite 102
Olympia, Washington 98501
206/753-9440 FTS 434-9440

July 17, 1991

Mr. Ihor Hlohowskyj
Argonne National Laboratory
9700 South Cass Avenue, Building 900
Argonne, Illinois 60439

FWS Reference
1-3-91-SP-407

Dear Mr. Hlohowskyj:

As requested by your letter, dated June 5, 1991 and received in this office on June 17, enclosed is a list of endangered and threatened species that may be present in the area of the proposed contaminant disposal site at the 200 West area of the Hanford site in Benton County, Washington. The list fulfills the requirement of the Fish and Wildlife Service under Section 7(c) of the Endangered Species Act of 1973, as amended. We are also enclosing the requirements for Department of Energy compliance under the Act.

Should the biological assessment determine that a listed species is likely to be affected (adversely or beneficially) by the project, the Department of Energy should request formal Section 7 consultation through this office. If the biological assessment determines that the proposed action is "not likely to adversely affect" a listed species, the Department of Energy should request Fish and Wildlife Service concurrence with that determination through the informal consultation process. Even if the biological assessment shows a "no effect" situation, we would appreciate receiving a copy for our information.

Also included is a list of candidate species presently under review by this Service for consideration as endangered or threatened. Candidate species are included simply as advance notice to federal agencies of species which may be proposed and listed in the future. However, protection provided to candidate species now may preclude possible listing in the future. If early evaluation of your project indicates that it is likely to adversely impact a candidate species, the Department of Energy may wish to request technical assistance from this office.

Your interest in endangered species is appreciated. If you have additional questions regarding your responsibilities under the Act, please contact Jeff Haas or Rich Carlson of my staff at the letterhead phone/address.

Sincerely,

Nancy J. Gloman

Nancy J. Gloman
Acting Field Supervisor

rc/kr

Enclosures

c: USDOE, Richland
USFWS, Moses Lake (Kaumheimer)
USFWS, Boise (Parenti)
WDW, Olympia (Nongame)
WNHP, Olympia

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR WITHIN THE AREA OF THE PROPOSED CONTAMINANT DISPOSAL SITE AT THE 200 WEST AREA OF THE HANFORD SITE IN BENTON COUNTY, WASHINGTON
(Located in various sections of T12/13N R26E)

LISTED

Peregrine falcon (*Falco peregrinus*) - spring and fall migrants may occur in the vicinity of the project from September to April.

Bald eagle (*Haliaeetus leucocephalus*) - wintering bald eagles may occur in the vicinity of the project from about October 31 through March 31.

Major concerns that should be addressed in your biological assessment of project impacts to listed species are:

1. Level of use of the project area by listed species.

2. Effect of the project on the listed species' primary food stocks and foraging areas in all areas influenced by the project.

3. Impacts from contaminant disposal (i.e., loss or degradation of habitat, increased noise levels, increased human activity) which may result in disturbance to listed species and/or their avoidance of the project area.

PROPOSED

None

CANDIDATE

Ferruginous hawk (*Buteo regalis*) - may occur in the vicinity of the project area.

Long-billed curlew (*Numenius americanus*) - may occur in the vicinity of the project area.

Western sage grouse (*Centrocercus urophasianus phaios*) - may occur in the vicinity of the project area.

Rorippa columbiae - (Columbia yellow-cress) - may occur in the vicinity of your project at T13N R26 S33/34.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Fish and Wildlife Enhancement
Columbia Field Office
608 East Cherry Street
Columbia, Missouri 65201

IN REPLY REFER TO:

FWS/AFWE-CMFO

OCT 0 1 1992

Dr. Ihor Hlohowskyj
Argonne National Laboratory
Environmental Assessment and Information Sciences Division
9700 South Cass Avenue
Building 900
Argonne, Illinois 60439

Dear Dr. Hlohowskyj:

This responds to our telephone conversation on September 25, 1992 requesting information on endangered species in the vicinity of the Weldon Springs hazardous waste site.

These comments are provided as technical assistance and predevelopment consultation and do not constitute a U.S. Fish and Wildlife Service report under authority of the Fish and Wildlife Coordination Act (Coordination Act) (16 U.S.C. 661 et seq.) on any required Federal environmental review or permit or license application.

We have reviewed the project area and have made the following determinations on endangered species:

1. The bald eagle (*Haliaeetus leucocephalus*) utilizes the Missouri River as a food source and roosting sites in the winter months. The eagle has been sited in St. Charles county on the last 6 bald eagle winter counts. There has been an average of 25 birds sited in the county each year.

2. Decurrent false aster (*Boltonia decurrens*) is in St. Charles county north of the project site. It has not been documented to be at Weldon Springs.

3. The pallid sturgeon (*Scaphirhynchus albus*) was listed as endangered since your last contact with this office. There are historical records of the sturgeon in the Missouri River near the project site.

4. The easter massasauga (*Sistrurus catenatus catenatus*), a category 2 candidate species[2], has been documented to be in St. Charles county.

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[2]Category 2 candidate species are those for which the Service is seeking additional information in order to determine their biological status; few Category 2 candidate species are proposed for listing. Candidate species have

5. The sicklefin chub (*Macrohybopsis meeki*) and sturgeon chub (*M. gelida*), also category 2 candidate species, have been found in the Missouri River below Weldon Springs.

Should you have questions concerning this response, or if we can be of any further assistance, please contact Ms. Colette Charbonneau at the address above, or by telephone at (314) 876-1911.

Sincerely yours,

Tom Nash

for Jerry J. Brabander
Field Supervisor

cc: MDC; Jefferson City, MO (Attn: Dan Dickneite)
MDC; Jefferson City, MO (Attn: Dennis Figg)
MDNR; Jefferson City, MO (Attn: Charles Stiefermann)
EPA; Kansas City, KS (Attn: Kathy Mulder)

CSC:cc:1156/STWELSPR

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no legal protection under the Endangered Species Act and are included in this document for planning purposes only.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL CRITERIA AND ASSESSMENT OFFICE
CINCINNATI, OHIO 45268

AUG 29 1990

Subject: Human Health Evaluation for the Weldon Spring NPL Site (Weldon Spring, Missouri)

From: Pei-Fung Hurst, Coordinator
Superfund Health Risk Technology Support Center
Chemical Mixtures Assessment Branch

To: Dan Wall
U.S. EPA
Region VII

Thru: W. Bruce Peirano
Acting Chief
Chemical Mixtures Assessment Branch

This memo is a draft response to the request of Lynne Haroun of Argonne National Lab who is currently working on Weldon Spring NPL Site in your region.

Attached please find the information requested. Feel free to contact me at FTS 684-7300 if I can be of further assistance.

Attachment

cc: D. Crawford (Region VII)
C. DeRosa (ECAO-Cin)
S. McCracken (DOE-WSS)
B. Means (OS-230)
T. O'Bryan (OS-230)

Review for the Weldon Spring NPL Site

1. Inhalation Reference Concentrations

Antimony. Not available.

Arsenic. Not available.

Beryllium. Not available.

Cadmium. Not available. ATSDR derived a chronic MRL of 0.0007 mg/cu.m. for renal effects in humans.

Chromium (III, VI). Currently not available. The inhalation RfC is being reviewed by OHEA and an interim value might be available near the end of August.

Cobalt. Not available.

Copper. Not available.

Lead. Not available (see discussion of oral RfD).

Lithium. Not available.

Mercury. There is a verified inhalation RfC of 0.0003 mg/cu.m. for inorganic mercury. The critical effect was neurotoxicity in humans. This RfC is pending input into IRIS. ATSDR derived a chronic MRL of 0.0003 mg/cu.m. for metallic mercury.

Molybdenum. A recent HEED (U.S. EPA, 1990) indicated that no inhalation data were adequate for derivation of criteria.

Nickel. Not available. ATSDR derived an MRL for intermediate duration exposure based on immunotoxic effects in rats, but the exact value was not specified.

Selenium. Not available. A recent HEED (U.S. EPA, 1989) concluded that there is insufficient inhalation data for deriving criteria.

Silver. Not available.

Thallium. Not available. A recent HEED (U.S. EPA, 1988) concluded that there is insufficient inhalation data for deriving criteria.

Uranium. Not available.

Vanadium. Not available.

2,4- and 2,6-Dinitrotoluene. Not available.

1,3,5-Trinitrobensene. A HEED (U.S. EPA, 1989) concluded that there is insufficient data for deriving criteria.

2,4,6-Trinitrotoluene. Not available.

Polychlorinated biphenyls (PCBs). Not available.

With regard to the use of OSHA or AGCIH values as inquired by Ms. Lynne Haroun our view is the following. Threshold Limit Values are derived with the purpose of protecting healthy workers from occupational disease and are not recommended for deriving health criteria for the general population, which may include highly sensitive subgroups that are not represented in the work force (e.g. children). Furthermore, the procedures used to derive OSHA or AGCIH values do not conform with current EPA methodology and guidelines regarding inhalation reference concentrations.

2. Oral Reference Doses

Cobalt. Not available.

Lead. Not available. It appears that some of the effects associated with lead exposures, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood levels so low as to be essentially without a threshold. The Agency's RfD Workgroup has discussed inorganic lead (and lead compounds) at two meetings and considered it inappropriate to develop RfDs for inorganic lead. However, an Uptake/Biokinetic Model for lead has been developed by ECAO and we can run the model for you with site-specific values.

Lithium. Not available. TSC recently derived a provisional chronic oral RfD of 20 µg/kg/day for lithium based on nephrotoxic effects in humans receiving long-term lithium therapy. Detailed information is available upon request.

2,4- and 2,6-Dinitrotoluene. TSC recently derived interim chronic oral RfDs of 2 µg/kg/day and 4 µg/kg/day for 2,4- and 2,6-dinitrotolune, respectively. These two values were derived from NOAELs for systemic effects in dogs. Detailed information is available upon request.

Polychlorinated biphenyls (PCBs). Not available. A chronic oral RfD of 0.0001 mg/kg/day was derived in a Drinking Water Quality Criteria (U.S. EPA, 1988) for developmental effects in monkeys treated with Arochlor 1016.

3. Inhalation Slope Factors

2,4,6-Trinitrotoluene. Not available.

2,4- and 2,6-Dinitrotoluene. Not available.

Polynuclear aromatic hydrocarbons. Not available on IRIS. As a conservative assumption, it is appropriate to use the inhalation slope factor of 6.1/(mg/kg/day) that was derived for benzo[a]pyrene in a 1984 HEA as an interim value.

Polychlorinated biphenyls (PCBs). Not available. The inhalation slope factor for PCBs is currently under discussion by the CRAVE Workgroup at the EPA.

Lead. Not available. Quantitative estimates of carcinogenic risk from exposure to lead are not available because of the many uncertainties involved, and some of them may be unique to lead. A brief summary of relevant issues follow.

1. Cross-species Extrapolation

Lead absorption, metabolism, distribution and excretion through the renal and gastrointestinal tracts have all been shown to vary across animal species. Therefore, a credible cross-species extrapolation from animal studies to estimate the cancer potency for humans should include cross-species pharmacokinetic modeling.

2. Routes of Exposure

Although it appears that all routes of exposure can result in absorption of lead to some extent, the route of exposure affects the degree of absorption. The absorption of inhaled lead further depends on particle size and ventilation rate. The injection and ingestion routes of exposure induce tumors at a common site (i.e., kidney). This suggests that lead is distributed to the same target sites, despite differences in the route of exposure.

3. Forms of Lead

Although all lead compounds can be absorbed to some extent, several studies have shown that the nonlead moiety of a lead compound can affect its absorption.

4. Bioavailability

Under acidic conditions, several lead compounds are converted to compounds such as lead chloride, which is more readily absorbed than the parent compound.

5. Dose

Absorption in rats 4 hours after gavage administration of lead is about 5% over doses ranging from 1 ug to 10 ug, but falls off to 1% at 1 mg.

6. Nutritional State

Deficiencies in certain essentials nutrients, such as low levels of calcium phosphate, vitamin D, iron, copper, or zinc, can enhance lead absorption, influence distribution, or decrease excretion.

7. Age

Children absorb 50% of ingested lead, compared with between 10 and 15% for adults. The fraction of absorbed lead retained in the body ranges from 1-5% in adults to 32-34% in young children. It is not clear how lifetime exposure studies can be used to make inferences about cancer risks rising from childhood exposure.

8. Types of Tumors

A few studies conducted at doses well below the maximum tolerated dose suggest that lead may also induce cerebral gliomas, testicular tumors, reticulum cell sarcomas and various other tumors. The evidence for these other tumors is much weaker than that for kidney tumors, however, these studies do suggest that lead may act to induce cancer at a variety of sites, at lower exposure levels than those that cause kidney tumors.

4. Oral Slope Factors

Polynuclear aromatic hydrocarbons. Not available (see inhalation slope factors). The Ambient Water Criteria Document (U.S. EPA, 1980) and Health Effects Assessment Document (U.S. EPA, 1984) derived an oral slope factor of 11.5/(mg/kg/day) using a linearized multistage procedure. This value could be adopted as an interim value for the risk assessment of Superfund sites.

Chromium(VI). Not available. There is inadequate evidence for carcinogenicity of this compound by the oral route.

Lead. Not available (see inhalation slope factors).

5. Dermal Route of Exposure

Of the metals listed under # 1 above, dermal absorption of mercury (metallic form) represents a potential hazard to human

health. Cobalt and Nickel are skin sensitizers. Arsenic and Copper may produce contact dermatitis.

The following is a summary of issues related to the risk assessment of the pathway.

Because toxicity values for dermal exposure are generally not available, current EPA methods specify that dermal toxicity values are to be extrapolated only from values derived for oral exposure. Adequate dermal toxicity data are sometimes available for carcinogenicity (e.g., skin painting studies). These studies can be used to support or oppose the appropriateness of route-to-route extrapolation, but there is currently no EPA method for using dermal data as the basis for a toxicity value. Since dermal exposure is expressed as an absorbed dose, oral toxicity values used for dermal risk assessment must also be expressed as an absorbed dose. Most oral toxicity values are expressed as administered doses and therefore will require absorption adjustment. Slope factors are adjusted to an absorbed dose by dividing by percent oral absorption, and reference doses are adjusted by multiplying by percent oral absorption. A conservative assumption for oral absorption in the absence of appropriate information is 5% (Risk Assessment Guidance for Superfund, 1989). However, if the actual oral absorption efficiency is higher, use of the default value of 5% will underestimate the absorbed dose toxicity value. This could be by a factor of as high as 20 if absorption efficiency is 100%.

Permeability constants, dermal absorption factors and adherence factors can have a significant effect on the magnitude of dermal absorbed doses. Oral absorption factors can similarly influence absorbed dose slope factors. The choice of factors and constant values therefore can have a pronounced effect, perhaps several orders of magnitude variation on cancer risk estimates.

If the response that is the basis for the oral (or inhalation) risk assessment is at the portal of entry, extrapolation to the dermal route on the basis of absorbed dose is not appropriate. Similarly, if the site of critical effect of dermal exposure to the compound is the skin, and the available oral (or inhalation) risk assessment is based on systemic effects, extrapolation from oral to dermal is not appropriate. A possible exception to this guidance would be the special case where the target organ for oral or inhalation exposure is the skin. For example, oral exposure to arsenic causes skin cancer in humans; dose-response data for this effect are the basis for the oral unit risk. Extrapolation of this unit risk to dermal exposure may be appropriate, but the available pharmacokinetics and mechanism-of-action data for arsenic should be considered.

If the critical effect reflected in the oral (or inhalation) risk assessment is specific to that route (i.e., there is evidence

that it does not occur during dermal exposure, or, in the absence of dermal data, that it does not occur following exposure to the chemical by other routes), the extrapolation is probably not appropriate.

Pharmacokinetic or mechanism-of-action data may be useful in deciding whether an effect is likely to be route-specific. For example, following oral administration, the total absorbed dose usually passes through the liver before entering the systemic circulation. Compounds that are toxic to the liver and/or that are sequestered and metabolized efficiently by the liver may have a greater toxic effect on the liver and may have fewer and less severe effects elsewhere in the body when administered orally than when administered dermally (or by inhalation). Confidence in the extrapolation of an oral toxicity value to the dermal route would be lower for these compounds than for compounds that are not toxic to or efficiently metabolized by the liver.

Norman H. Bangerter
Governor
Dee C. Hansen
Executive Director
Timothy H. Provan
Division Director

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WILDLIFE RESOURCES

Central Region
1115 North Main Street
Springville, Utah 84663-1055
801-489-5678

June 19,1991

Mr. Christopher Dunn
Argonne National Laboratory
Bldg. 900
9700 So. Cass Ave.
Argonne, Ill. 60439

Dear Mr. Dunn,

The enclosed material is provided as per your request for information regarding threatened and endangered plant and animal species affected by the construction and operation of a hazardous waste incinerator at Clive, Utah. The material is taken from the Final Environmental Impact Statement for USPCI Clive Incineration Facility (June 1990).

Please contact me if you need additional information.

Sincerely,

John Fairchild

John Fairchild
Habitat Manager

an equal opportunity employer

A variety of non-game mammals, birds, and reptiles are supported by habitats found in the proposed project area and associated utility, railroad, and access road ROWs. Species that may occur include the Townsend's ground squirrel, Ord's kangaroo rat, desert woodrat, western harvest mouse, side-blotched lizard, gopher snake, Brewer's sparrow, black-throated sparrow, and horned lark (BLM 1982 and 1987).

Aquatic ecosystems do not occur on the Clive site.

3.2.4.3 Threatened, Endangered, or Special Status Species. No federal or state-listed threatened, endangered, or candidate plant species are known to occur within the Clive project area (Snyder 1989; BLM 1983, 1987, and 1988b).

The bald eagle and American peregrine falcon are federally-listed endangered species that could occur within the project area (Benton 1989; USFWS 1987). The bald eagle is a winter resident from late November to mid-March in the project vicinity. The majority of wintering eagles are found in Rush Valley with others occurring in Skull and Cedar Valleys. No bald eagle roosts are located within the proposed project area; however, the black-tailed jackrabbit is the primary food source utilized by bald eagles in Tooele County (Benton 1989; BLM 1988b), and eagles may potentially hunt within this area.

One historical eyrie of the American peregrine falcon was located near Timpie Springs Wildlife Management Area (WMA) in the northern end of the Stansbury Mountains. The nest site became inactive following the construction of I-80 in the late 1960s (Benton 1989; BLM 1988b). In an attempt to re-establish a breeding pair of peregrines, the Utah Division of Wildlife Resources, in cooperation with the U.S. Fish and Wildlife Service (USFWS), erected a hack site at the Timpie Springs WMA, approximately 26 miles from the Clive site. The hack site became active in 1983 and 1984, and a peregrine pair was observed using the site in Spring 1987. The hack site was occupied in 1989 by a nesting pair of peregrines (Benton 1989). Peregrines are known to arrive in the area in March and, if nesting, may remain until September (Benton 1989). Due to the distance between the Clive site and the eyrie, it is unlikely any peregrines utilize the project area.

The ferruginous hawk and Swainson's hawk occur within the project area (Benton 1989) and are both listed as federal candidate species (C2 and 3C, respectively) and state-listed candidate species (USFWS 1989). Other raptors commonly found in the area include the golden eagle, prairie falcon, turkey vulture, red-tailed hawk, and burrowing owl. No nesting raptors have been identified within 0.5 mile of the facility site (Nelson 1989).

The Cedar Mountains contain a wild horse herd protected under the Wild and Free Roaming Horse and Burro Act of 1971. The Cedar Mountain herd presently contains an estimated 125 horses and extends from 4 miles north of Eight Mile Spring to the southern portion of the Cedar Mountain range (BLM 1988b). Wild horses are seldom encountered on the Clive site (Kidd 1989). The state sensitive kit fox may occur throughout the West Desert Hazardous Industry Area (Johnston 1989).

3.2.5 Transportation

The proposed Clive site is located approximately 3 miles south of I-80, and approximately 70 road miles west of Salt Lake City. The only access to the site from both the east and west is provided by I-80 which is a 4-lane, divided highway. Road conditions along this section of I-80 are generally well maintained. Regional access to the site is also provided by I-15 and I-84 which travel in a north/south direction. While there is an existing freeway overpass near the Clive site, there is no permanent interchange on I-80 that provides direct access to the Clive site. Existing truck traffic reaches the Envirocare and Vitro tailings site in Section 32 by pulling off I-80 onto a temporary dirt exit road. The west-bound exit and east-bound entrance roads were temporarily established for the Vitro tailings project and are posted for authorized vehicles only.

Traffic count data are available for I-80 from the Utah Department of Transportation. Annual average daily traffic (AADT) for several locations along I-80 are listed in Table 3-5. The AADT data show that in 1987 traffic was fairly uniform along I-80 and exhibited a gradual increase from west to east. Traffic increased at these locations by approximately 7 to 9 percent between 1986 and 1987. There are currently 20 trains per day on Union Pacific's tracks west of Salt Lake City (Alder 1989).