APPENDIX E:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR PREPARING CYLINDERS FOR SHIPMENT OR LONG-TERM STORAGE

CONTENTS (APPENDIX E)

TABLES

TABLES (Cont.)

FIGURES

FIGURES (Cont.)

NOTATION (APPENDIX E)

The following is a list of acronyms and abbreviations, including units of measure, used in this document. Some acronyms used only in tables are defined in those tables.

ACRONYMS AND ABBREVIATIONS

General

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
HEPA	high-efficiency particulate air (filter)
LCF	latent cancer fatality
LLNL	Lawrence Livermore National Laboratory
LLMW	low-level mixed waste
LLW	low-level radioactive waste
MCL	maximum contaminant level
MEI	maximally exposed individual
NEPA	*National Environmental Policy Act*
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
PEIS	programmatic environmental impact statement
PM_{10}	particulate matter with a mean diameter of 10 µm or less
ROI	region of influence

Chemicals

CO	carbon monoxide
HC	hydrocarbons
HF	hydrogen fluoride
NaOH	sodium hydroxide
NO_x	nitrogen oxides
UF_6	uranium hexafluoride
UO_2F_2	uranyl fluoride
$UO_2(OH)_2$	uranyl hydroxide

UNITS OF MEASURE

Ci	curie(s)	m	meter(s)
ft	foot (feet)	m^3	cubic meter(s)
ft^2	square foot (feet)	min	minute(s)
ft^3	cubic foot (feet)	mrem	millirem(s)
gal	gallon(s)	pCi	picocurie(s)
gpm	gallon(s) per minute	rem	roentgen equivalent man
GWh	gigawatt-hour(s)	s	second(s)
ha	hectare(s)	scf	standard cubic foot (feet)
kg	kilogram(s)	ton(s)	short ton(s)
L	liter(s)	yd^3	cubic yard(s)
lb	pound(s)	yr	year(s)
µg	microgram(s)		
µm	micrometer(s)		

APPENDIX E:

ENVIRONMENTAL IMPACTS OF OPTIONS FOR PREPARING CYLINDERS FOR SHIPMENT OR LONG-TERM STORAGE

The U.S. Department of Energy (DOE) is proposing to develop a strategy for long-term management of the depleted uranium hexafluoride (UF_6) inventory currently stored at three DOE sites in Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. This programmatic environmental impact statement (PEIS) describes alternative strategies that could be used for the long-term management of this material and analyzes the potential environmental consequences of implementing each strategy for the period 1999 through 2039. This appendix provides detailed information describing the cylinder preparation options considered in the PEIS. The discussion provides background information for these options, as well as a summary of the estimated environmental impacts associated with each option.

> **Cylinder Preparation Options**
>
> Cylinder preparation refers to the activities necessary to prepare depleted UF_6 cylinders for off-site transportation. Depleted UF_6 cylinders were designed, built, tested, and certified to meet U.S. Department of Transportation (DOT) requirements for shipment by truck and rail. However, after several decades in storage, some cylinders no longer meet these requirements. Two options for preparing these cylinders for shipment are considered in the PEIS.
>
> **Cylinder Overcontainers.** Cylinders that do not meet DOT requirements could be placed inside protective metal "overcontainers" for shipment. These reusable overcontainers, which would be slightly larger than a cylinder, would be designed to meet all DOT requirements.
>
> **Cylinder Transfer.** In this option, the depleted UF_6 in cylinders that do not meet DOT requirements would be transferred to new cylinders capable of being transported.
>
> Note: For both options, cylinders that meet DOT shipment requirements would be shipped directly.

The term "cylinder preparation" refers to the activities necessary to prepare depleted UF_6 cylinders for off-site transportation. Under the PEIS alternative management strategies, transportation of depleted UF_6 cylinders was assumed to be required from the three current cylinder storage sites to either (1) a conversion facility or (2) a long-term storage site (for long-term storage of UF_6). UF_6 cylinders have been transported safely by truck and rail between DOE facilities, electric utilities, reactor fuel fabricators, and research nuclear reactors for about 40 years.

Depleted UF_6 cylinders were designed, built, tested, and certified to meet U.S. Department of Transportation (DOT) requirements for shipment by truck and rail. The DOT requirements, specified in Title 49 of the *Code of Federal Regulations* (CFR), are intended to maintain the safety of shipments during both routine and accident conditions. Cylinders meeting the DOT requirements could be loaded directly onto specially designed truck trailers or railcars for shipment. However, after several decades in storage, some cylinders no longer meet the DOT requirements. Two cylinder preparation options, which address different approaches that could be used to transport the depleted UF_6 stored in these cylinders, are considered in the PEIS. These two options, discussed in detail in Section E.2, are a cylinder overcontainer option and a cylinder transfer option.

It is unknown exactly how many of the depleted UF_6 cylinders currently do not meet the DOT transportation requirements. The potential problems with cylinders are related to three DOT requirements that must be satisfied before shipment: (1) cylinders must be filled to less than 62% of the maximum capacity (the fill-limit was reduced to 62% from 64% around 1987); (2) the pressure within cylinders must be less than atmospheric pressure; and (3) cylinders must be free of damage or defects, such as dents, and have a specified minimum wall thickness. Cylinders not meeting these requirements are referred to as overfilled, overpressurized, and substandard, respectively. Some cylinders may fail to meet more than one requirement.

The assessment of cylinder preparation options in the PEIS considers the environmental impacts of preparing the entire DOE-generated depleted UF_6 cylinder inventory for shipment over a 20-year period. Prior to shipment, each cylinder would be inspected to determine if it meets DOT requirements. This inspection would include a record review to determine if the cylinder is overfilled; a visual inspection for damage or defects; a pressure check to determine if the cylinder is overpressurized; and an ultrasonic wall thickness measurement (if necessary based on the visual inspection). If a cylinder passed the inspection, the appropriate documentation would be prepared, and the cylinder would be loaded directly for shipment. If a cylinder failed the inspection, it would be prepared using one of the two cylinder preparation options (see Section E.2).

If cylinder shipment was necessary under the alternative selected, this activity would occur at each site (e.g., cylinders might be shipped to a conversion facility or to a long-term storage facility, assuming that the site(s) selected for these facilities were not the current storage locations). Therefore, the assessment of cylinder preparation options in this PEIS was designed to address the entire range of potential cylinder preparation needs at each of the three sites, as follows:

- ***Paducah Site:*** The estimated number of cylinders not meeting DOT requirements at the Paducah site would range from 9,600 to 28,351 (the entire Paducah inventory of DOE-generated cylinders). On the basis of this estimate, there would be a need to provide overcontainer or cylinder transfer capacities for about 480 to 1,420 cylinders annually and, conversely, to prepare from 0 to 940 standard cylinders per year for shipment.

- ***Portsmouth Site:*** The estimated number of cylinders not meeting DOT requirements at the Portsmouth site would range from 2,600 to 13,388 (the entire Portsmouth inventory of DOE-generated cylinders). On the basis of this estimate, there would be a need to provide overcontainer or cylinder transfer capacities for about 130 to 670 cylinders annually and to prepare from 0 to 540 standard cylinders per year for shipment.

- ***K-25 Site:*** The estimated number of cylinders not meeting DOT requirements at the K-25 site would range from 2,342 to 4,683 (the entire K-25 inventory). On the basis of this estimate, there would be a need to provide overcontainer or cylinder transfer capacities for about 120 to 234 cylinders annually and to prepare from 0 to 120 standard cylinders per year for shipment.

The environmental impacts from the cylinder preparation options were evaluated on the basis of information provided in the engineering analysis report (Lawrence Livermore National Laboratory [LLNL] 1997), i.e., preconceptual design data for each option, including descriptions of facility layouts; resource requirements; estimated effluents, wastes, and emissions; and potential accident scenarios. In the engineering analysis report, estimates for cylinder transfer operations ranged in capacity from 320 to 1,600 cylinders processed per year; whereas overcontainer and standard cylinder operations were addressed on a site-specific basis for a reference case for each site (i.e., 960 cylinders/yr with overcontainers for the Paducah site, 260 cylinders/yr with overcontainers for the Portsmouth site, and 234 cylinders/yr with overcontainers for the K-25 site), with some information provided on scaling up or down from the reference case (LLNL 1997). Supporting data for the overcontainer and transfer facility analyses were derived by Folga (1996b) using information provided in the engineering analysis report (LLNL 1997).

For assessment purposes, it was assumed that all cylinders would require transportation. However, the actual need for transportation of cylinders would depend on site selection and other considerations to be addressed in the second tier of the *National Environmental Policy Act* (NEPA) process.

E.1 SUMMARY OF CYLINDER PREPARATION OPTION IMPACTS

This section provides a summary of the potential environmental impacts associated with the cylinder preparation options. Additional discussion and details related to the assessment methodologies and results for individual areas of impact are provided in Section E.3.

Potential environmental impacts are summarized in Tables E.1, E.2, and E.3 for the Paducah, Portsmouth, and K-25 sites, respectively. Ranges of impacts are presented for the over-container option, the cylinder transfer option, and the preparation of standard cylinders (which is required for either option). Based on the information in Tables E.1 through E.3 and Section E.3, the following general conclusions may be drawn:

- For the cylinder overcontainer option and preparation of standard cylinders, impacts during normal operations would be small and limited to involved workers. No impacts to the off-site public or the environment would occur because no releases would be expected and no construction activities would be required.

TABLE E.1 Summary of Cylinder Preparation Impacts for the Paducah Site

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 170 – 510 person-rem Total number of LCFs: 0.07 – 0.2 LCF	**Involved Workers:** Total collective dose: 610 – 1,000 person-rem Total number of LCFs: 0.2 – 0.4 LCF	**Involved Workers:** Total collective dose: 0 – 220 person-rem Total number of LCFs: 0 – 0.09 LCF
Noninvolved Workers: No impacts	**Noninvolved Workers:** Annual dose to MEI : $1.9 \times 10^{-6} – 4.9 \times 10^{-6}$ mrem/yr Annual cancer risk to MEI: $8 \times 10^{-13} – 2 \times 10^{-12}$ per year Total collective dose: $5.1 \times 10^{-5} – 1.3 \times 10^{-4}$ person-rem Total number of LCFs: $2 \times 10^{-8} – 5 \times 10^{-8}$ LCF	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** Annual dose to MEI: $6.8 \times 10^{-6} – 1.7 \times 10^{-5}$ mrem/yr Annual cancer risk to MEI: $3 \times 10^{-12} – 9 \times 10^{-12}$ per year Total collective dose to population within 50 miles: $1.1 \times 10^{-3} – 2.9 \times 10^{-3}$ person-rem Total number of LCFs in population within 50 miles: $6 \times 10^{-7} – 1 \times 10^{-6}$ LCF	**General Public:** No impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts

TABLE E.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Accidents: Radiological		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Dose to MEI: 0.02 rem	Dose to MEI: 0.02 rem	Dose to MEI: 0.02 rem
Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}
Collective dose: 15 person-rem	Collective dose: 15 person-rem	Collective dose: 15 person-rem
Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Dose to MEI: 0.015 rem	Dose to MEI: 0.015 rem	Dose to MEI: 0.015 rem
Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}
Collective dose to population within 50 miles: 28 person-rem	Collective dose to population within 50 miles: 28 person-rem	Collective dose to population within 50 miles: 28 person-rem
Number of LCFs in population within 50 miles: 0.01 LCF	Number of LCFs in population within 50 miles: 0.01 LCF	Number of LCFs in population within 50 miles: 0.01 LCF
Human Health – Accidents: Chemical		
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 910 persons	Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 450 persons	Number of persons with potential for adverse effects: 910 persons
Number of persons with potential for irreversible adverse effects: 300 persons	Number of persons with potential for irreversible adverse effects: 330 persons	Number of persons with potential for irreversible adverse effects: 300 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1,900 persons	Number of persons with potential for adverse effects: 2,500 persons	Number of persons with potential for adverse effects: 1,900 persons
Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 1 person

TABLE E.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
	Human Health — Accidents: Physical Hazards	
Operations: **All Workers:** Less than 1 (0.029 – 0.087) fatality, approximately 39 – 115 injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.31 – 0.34) fatality, approximately 210 – 250 injuries	**Operations:** **All Workers:** Less than 1 (0 – 0.043) fatality, approximately 0 – 87 injuries
	Air Quality	
Construction: Not applicable	**Construction:** 24-hour PM_{10} impacts potentially as large as 62% of standard. Concentrations of other criteria pollutants all below 15% of respective standards.	**Construction:** Not applicable
Operations: Concentrations of all criteria pollutants below 0.08% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.08% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.03% of respective standards.
	Water	
Construction: Not applicable	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Not applicable
Operations: None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards
	Soil	
Construction: Not applicable	**Construction:** Negligible, but temporary, impacts	**Construction:** Not applicable
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
	Socioeconomics	
Preoperations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Preoperations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.

TABLE E.1 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
	Ecology	
Construction: Not applicable	**Construction:** Potentially moderate impacts to vegetation, wildlife, and wetlands	**Construction:** Not applicable
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** No impacts
	Waste Management	
No impacts on regional or national waste management operations	No impacts on regional or national waste management operations	No impacts on regional or national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected	No impacts from resource requirements (such as electricity or materials) on the local or national scale are expected
	Land Use	
No impacts	Use of approximately 21 acres; negligible impacts	No impacts
	Cultural Resources	
Construction: No impacts	**Construction:** Cannot be determined	**Construction:** No impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts

[a] Problem cylinders are cylinders not meeting DOT transportation requirements, either because they are (1) overfilled, (2) overpressurized, or (3) damaged or substandard with respect to wall thickness.

[b] These impacts must be added to those for either of the two options for preparation of problem cylinders.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 µm or less; ROI = region of influence.

TABLE E.2 Summary of Cylinder Preparation Impacts for the Portsmouth Site

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 47 – 240 person-rem Total number of LCFs: 0.02 – 0.1 LCF	**Involved Workers:** Total collective dose: 410 – 690 person-rem Total number of LCFs: 0.2 – 0.3 LCF	**Involved Workers:** Total collective dose: 0 – 120 person-rem Total number of LCFs: 0 – 0.05 LCF
Noninvolved Workers: No impacts	**Noninvolved Workers:** Annual dose to MEI : $1.9 \times 10^{-6} – 7.9 \times 10^{-6}$ mrem/yr Annual cancer risk to MEI: $7 \times 10^{-13} – 3 \times 10^{-12}$ per year Total collective dose: $2.6 \times 10^{-5} – 1.1 \times 10^{-4}$ person-rem Total number of LCFs: $1 \times 10^{-8} – 4 \times 10^{-8}$ LCF	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** Annual dose to MEI: $3.3 \times 10^{-5} – 4.4 \times 10^{-5}$ mrem/yr Annual cancer risk to MEI: 2×10^{-11} per year Total collective dose to population within 50 miles: $3.1 \times 10^{-4} – 1.3 \times 10^{-3}$ person-rem Total number of LCFs in population within 50 miles: $2 \times 10^{-7} – 7 \times 10^{-7}$ LCF	**General Public:** No impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts

TABLE E.2 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
	Human Health – Accidents: Radiological	
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Dose to MEI: 0.02 rem	Dose to MEI: 0.02 rem	Dose to MEI: 0.02 rem
Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}	Risk of LCF to MEI: 8×10^{-6}
Collective dose: 16 person-rem	Collective dose: 16 person-rem	Collective dose: 16 person-rem
Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}	Number of LCFs: 6×10^{-3}
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Dose to MEI: 0.015 rem	Dose to MEI: 0.015 rem	Dose to MEI: 0.015 rem
Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}	Risk of LCF to MEI: 7×10^{-6}
Collective dose to population within 50 miles: 32 person-rem	Collective dose to population within 50 miles: 32 person-rem	Collective dose to population within 50 miles: 32 person-rem
Number of LCFs in population within 50 miles: 0.02 LCF	Number of LCFs in population within 50 miles: 0.02 LCF	Number of LCFs in population within 50 miles: 0.02 LCF
	Human Health – Accidents: Chemical	
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):	**Noninvolved Workers:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 1,000 persons	Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 520 persons	Number of persons with potential for adverse effects: 1,000 persons
Number of persons with potential for irreversible adverse effects: 110 persons	Number of persons with potential for irreversible adverse effects: 440 persons	Number of persons with potential for irreversible adverse effects: 110 persons
General Public: Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):	**General Public:** Bounding accident consequences (per occurrence):
Number of persons with potential for adverse effects: 650 persons	Number of persons with potential for adverse effects: 580 persons	Number of persons with potential for adverse effects: 650 persons
Number of persons with potential for irreversible adverse effects: 1 person	Number of persons with potential for irreversible adverse effects: 0 persons	Number of persons with potential for irreversible adverse effects: 1 person

TABLE E.2 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health — Accidents: Physical Hazards		
Operations: **All Workers:** Less than 1 (0.007 – 0.041) worker fatality, approximately 10 – 54 worker injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.22 – 0.31) worker fatality, approximately 110 – 240 worker injuries	**Operations:** **All Workers:** Less than 1 (0 – 0.025) worker fatality, approximately 0 – 33 worker injuries
Air Quality		
Construction: Not applicable	**Construction:** 24-hour PM_{10} impacts potentially as large as 36% of standard. Concentrations of other criteria pollutants all below 7% of respective standards.	**Construction:** Not applicable
Operations: Concentrations of all criteria pollutants below 0.02% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.04% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.01% of respective standards.
Water		
Construction: Not applicable	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Not applicable
Operations: None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards
Soil		
Construction: Not applicable	**Construction:** Negligible, but temporary, impacts	**Construction:** Not applicable
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts
Socioeconomics		
Preoperations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Preoperations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.

TABLE E.2 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
	Ecology	
Construction: Not applicable	**Construction:** Potentially moderate impacts to vegetation, wildlife, and wetlands	**Construction:** Not applicable
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** No impacts
	Waste Management	
No impacts on regional or national waste management operations	No impacts on regional or national waste management operations	No impacts on regional or national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale
	Land Use	
No impacts	Use of approximately 14 acres; negligible impacts	No impacts
	Cultural Resources	
Construction: No impacts	**Construction:** Cannot be determined	**Construction:** No impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts

[a] Problem cylinders are cylinders not meeting DOT transportation requirements, either because they are (1) overfilled, (2) overpressurized, or (3) damaged or substandard with respect to wall thickness.

[b] These impacts must be added to those for either of the two options for preparation of problem cylinders.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 µm or less; ROI = region of influence.

TABLE E.3 Summary of Cylinder Preparation Impacts for the K-25 Site

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Normal Operations: Radiological		
Involved Workers: Total collective dose: 42 – 85 person-rem Total number of LCFs: 0.02 – 0.03 LCF	**Involved Workers:** Total collective dose: 410 – 480 person-rem Total number of LCFs: 0.2 LCF	**Involved Workers:** Total collective dose: 0 – 27 person-rem Total number of LCFs: 0 – 0.01 LCF
Noninvolved Workers: No impacts	**Noninvolved Workers:** Annual dose to MEI : $2.0 \times 10^{-6} – 3.7 \times 10^{-6}$ mrem/yr Annual cancer risk to MEI: $8 \times 10^{-13} – 2 \times 10^{-12}$ per year Total collective dose: $3.1 \times 10^{-5} – 5.6 \times 10^{-5}$ person-rem Total number of LCFs: $1 \times 10^{-8} – 2 \times 10^{-8}$ LCF	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** Annual dose to MEI: $2.4 \times 10^{-5} – 2.9 \times 10^{-5}$ mrem/yr Annual cancer risk to MEI: 1×10^{-11} per year Total collective dose to population within 50 miles: $9.8 \times 10^{-4} – 1.8 \times 10^{-3}$ person-rem Total number of LCFs in population within 50 miles: $5 \times 10^{-7} – 9 \times 10^{-7}$ LCF	**General Public:** No impacts
Human Health – Normal Operations: Chemical		
Noninvolved Workers: No impacts	**Noninvolved Workers:** No impacts	**Noninvolved Workers:** No impacts
General Public: No impacts	**General Public:** No impacts	**General Public:** No impacts

TABLE E.3 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
	Human Health – Accidents: Radiological	
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 16 person-rem Number of LCFs: 6×10^{-3}	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 16 person-rem Number of LCFs: 6×10^{-3}	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Dose to MEI: 0.02 rem Risk of LCF to MEI: 8×10^{-6} Collective dose: 16 person-rem Number of LCFs: 6×10^{-3}
General Public: Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 63 person-rem Number of LCFs in population within 50 miles: 0.03 LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 63 person-rem Number of LCFs in population within 50 miles: 0.03 LCF	**General Public:** Bounding accident consequences (per occurrence): Dose to MEI: 0.015 rem Risk of LCF to MEI: 7×10^{-6} Collective dose to population within 50 miles: 63 person-rem Number of LCFs in population within 50 miles: 0.03 LCF
	Human Health – Accidents: Chemical	
Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years	Bounding accident frequency: 1 in 10,000 years to 1 in 1 million years
Noninvolved Workers: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 770 persons Number of persons with potential for irreversible adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 140 persons	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 500 persons Number of persons with potential for irreversible adverse effects: 190 persons	**Noninvolved Workers:** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 770 persons Number of persons with potential for irreversible adverse effects (bounding accident frequency: 1 in 100 years to 1 in 10,000 years): 140 persons

TABLE E.3 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		Impacts from Preparation of Standard Cylinders[b]
Cylinder Overcontainer Operations	Cylinder Transfer Operations	
Human Health – Accidents: Chemical (Cont.)		
General Public: Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 550 persons Number of persons with potential for irreversible adverse effects: 0 persons	**General Public:** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 980 persons Number of persons with potential for irreversible adverse effects: 0 persons	**General Public:** Bounding accident consequences (per occurrence): Number of persons with potential for adverse effects: 550 persons Number of persons with potential for irreversible adverse effects: 0 persons
Human Health — Accidents: Physical Hazards		
Operations: **All Workers:** Less than 1 (0.007 – 0.014) worker fatality, approximately 9 – 18 worker injuries	**Construction and Operations:** **All Workers:** Less than 1 (0.17 – 0.21) worker fatality, approximately 94 – 140 worker injuries	**Operations:** **All Workers:** Less than 1 (0 – 0.006) worker fatality, approximately 0 – 7 worker injuries
Air Quality		
Construction: Not applicable	**Construction:** 24-hour PM_{10} impacts potentially as large as 87% of standard. Concentrations of other criteria pollutants all below 11% of respective standards.	**Construction:** Not applicable
Operations: Concentrations of all criteria pollutants below 0.01% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.07% of respective standards.	**Operations:** Concentrations of all criteria pollutants below 0.004% of respective standards.
Water		
Construction: Not applicable	**Construction:** Negligible impacts to surface water and groundwater	**Construction:** Not applicable
Operations: None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards	**Operations:** None to negligible impacts for runoff, floodplains, recharge, and depth to groundwater; estimated surface water and groundwater concentrations would not exceed drinking water standards
Soil		
Construction: Not applicable	**Construction:** Negligible, but temporary, impacts	**Construction:** Not applicable
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts

TABLE E.3 (Cont.)

Impacts from Preparation of Problem Cylinders[a]		
Cylinder Overcontainer Operations	Cylinder Transfer Operations	Impacts from Preparation of Standard Cylinders[b]
	Socioeconomics	
Preoperations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Construction:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Preoperations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
Operations: Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.	**Operations:** Negligible to low impacts to ROI employment and population growth rates, vacant housing, and public finances.
	Ecology	
Construction: Not applicable	**Construction:** Potentially moderate impacts to vegetation, wildlife, and wetlands	**Construction:** Not applicable
Operations: Negligible impacts	**Operations:** Negligible impacts	**Operations:** No impacts
	Waste Management	
No impacts on regional or national waste management operations	No impacts on regional or national waste management operations	No impacts on regional or national waste management operations
	Resource Requirements	
No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale	No impacts from resource requirements (such as electricity or materials) on the local or national scale
	Land Use	
No impacts	Use of approximately 12 acres; negligible impacts	No impacts
	Cultural Resources	
Construction: No impacts	**Construction:** Cannot be determined	**Construction:** No impacts
Operations: No impacts	**Operations:** No impacts	**Operations:** No impacts

[a] Problem cylinders are cylinders not meeting DOT transportation requirements, either because they are (1) overfilled, (2) over-pressurized, or (3) damaged or substandard with respect to wall thickness.

[b] These impacts must be added to those for either of the two options for preparation of problem cylinders.

Notation: LCF = latent cancer fatality; MEI = maximally exposed individual; PM_{10} = particulate matter with a mean diameter of 10 µm or less; ROI = region of influence.

- For the cylinder transfer option, impacts during construction and normal operations would generally be small and limited primarily to involved workers. Some small off-site releases of hazardous and nonhazardous materials would occur, although these would have negligible impacts on the off-site public and environment. Construction activities could temporarily impact air quality, but concentrations of criteria pollutants would all be within standards.

- For both options, there is a potential for low-probability accidents (UF_6 cylinders engulfed in a fire) that could have large consequences. The accident impacts would be limited primarily to workers, but off-site impacts are possible.

E.2 DESCRIPTION OF OPTIONS

This section provides a brief summary of the cylinder preparation options considered in the assessment of impacts. The information is based on preconceptual design data provided in the engineering analysis report (LLNL 1997). The engineering analysis report includes much more detailed information, including descriptions of facility layouts, resource requirements, estimates of effluents, wastes, and emissions, and descriptions of potential accident scenarios.

Prior to shipment, each cylinder would be inspected to determine if it meets DOT requirements. This inspection would include a record review to determine if the cylinder is overfilled; a visual inspection for damage or defects; a pressure check to determine if the cylinder is overpressurized; and an ultrasonic wall thickness measurement (if necessary based on the visual inspection). If a cylinder passed the inspection, the appropriate documentation would be prepared, and the cylinder would be loaded directly for shipment.

The preparation of standard cylinders for shipment (cylinders that meet DOT requirements) would include inspection activities, unstacking, on-site transfer, and loading onto a truck trailer or railcar. The cylinders would be secured using the appropriate tiedowns, and the shipment would be labeled in accordance with DOT requirements. Handling and support equipment and procedures for on-site movement and loading the cylinders would be of the same type currently used for cylinder management activities at the three storage sites.

E.2.1 Cylinder Overcontainers

Cylinder overcontainers are one option for transporting cylinders that do not meet DOT requirements. An overcontainer is simply a container into which a cylinder would be placed for shipment. The metal overcontainer would be designed, tested, and certified to meet all DOT shipping requirements. The overcontainer would be suitable to contain, transport, and store the cylinder contents regardless of cylinder condition. In addition, the overcontainers could be designed as pressure vessels, enabling the withdrawal of the depleted UF_6 from the cylinder in an autoclave (a device used to heat cylinders using hot air).

The type of overcontainer evaluated in the PEIS, shown in Figure E.1, is a horizontal "clamshell" vessel (LLNL 1997). For transportation, a cylinder not meeting DOT requirements would be placed into an overcontainer already on a truck trailer or railcar. The overcontainer would be closed, secured, and the shipment would be labeled in accordance with DOT requirements. The handling and support equipment for on-site movement and loading the cylinder into the

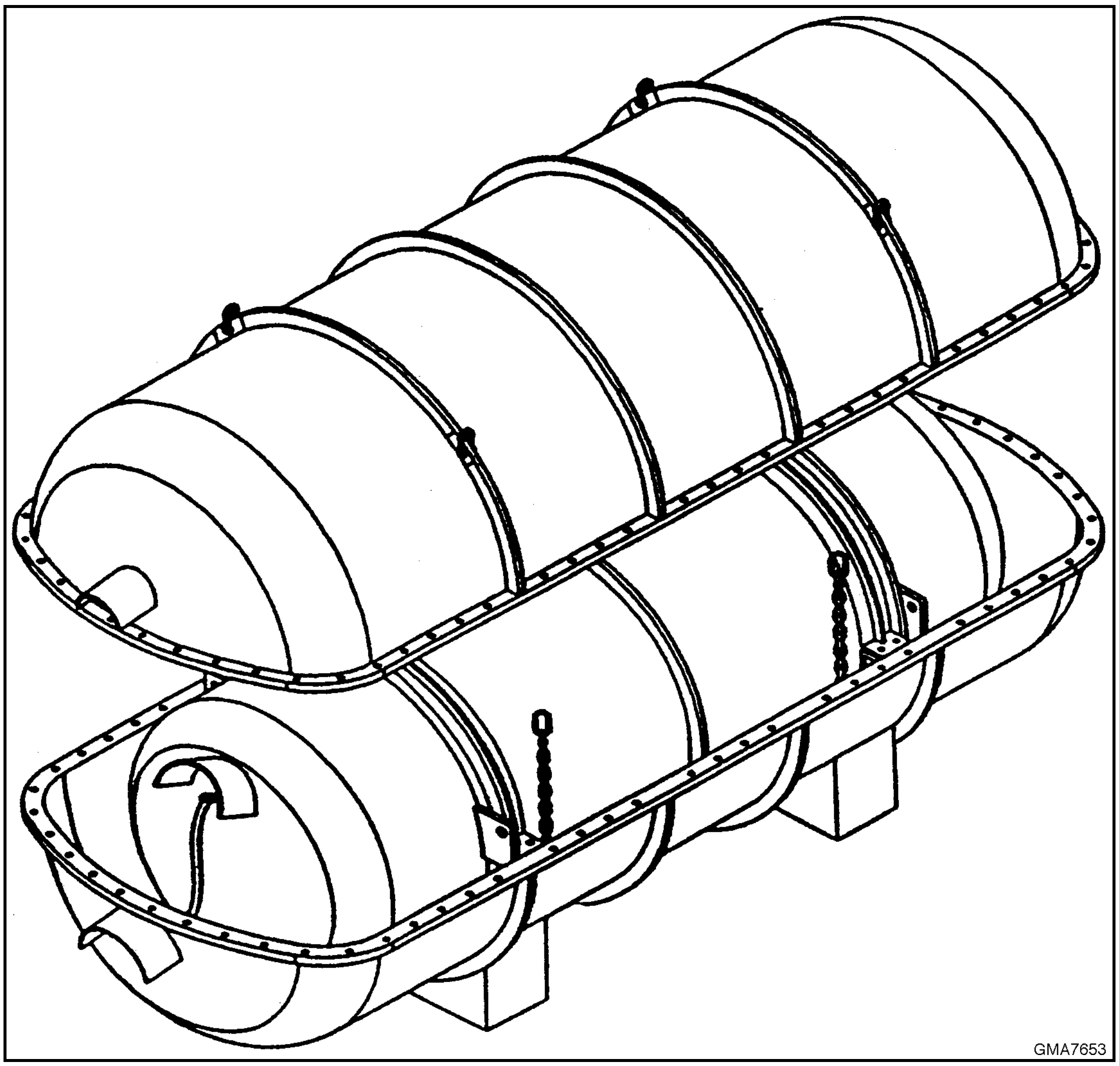

FIGURE E.1 Horizontal "Clamshell" Overcontainer for Transportation of Cylinders Not Meeting DOT Requirements (Source: LLNL 1997)

overcontainer would be of the same type currently used for cylinder management activities at the three DOE sites. The overcontainers could be reused following shipment. The overcontainer option would not require the construction of new facilities.

E.2.2 Cylinder Transfer

A second option for transporting cylinders that do not meet DOT requirements would be to transfer the depleted UF_6 from substandard cylinders to new cylinders that meet all DOT requirements. This option would require the construction of a new facility. A representative transfer facility is shown in Figure E.2. The transfer facility would be a stand-alone facility capable of receiving cylinders, storing a small number of cylinders, and transferring the contents to new cylinders. The transfer of depleted UF_6 would take place in a process building by placing substandard cylinders into autoclaves. The autoclaves would be used to heat the contents of the cylinder (using hot air), forming UF_6 gas which then would be piped to a new cylinder. The new cylinders could be shipped by placing them directly on appropriate trucks or railcars. The empty cylinders would be cleaned and treated with other scrap metals. (See Appendix F for details on the treatment of empty cylinders.)

E.3 IMPACTS OF OPTIONS

This section provides a summary of the potential environmental impacts associated with the cylinder preparation options, including impacts from construction (of a cylinder transfer facility), and during operations. Information related to the assessment methodologies for each area of impact is provided in Appendix C.

The environmental impacts from the cylinder preparation options were evaluated on the basis of the information described in the engineering analysis report (LLNL 1997) and Folga (1996a). The following general assumptions apply to the assessment of impacts:

- The assessment considers preparation of cylinders that meet DOT requirements (standard cylinders), as well as those cylinders that do not meet the requirements.

- Evaluation of standard cylinder preparation and the cylinder overcontainer option includes only an operational phase — no construction activities would be required. Additionally, these options would not generate emissions of uranium compounds or hydrogen fluoride (HF) during normal operations.

- The evaluation of the cylinder transfer option includes construction of a facility in addition to operations. The operation of a cylinder transfer facility would involve small releases of uranium compounds and HF as air and water effluents during normal operations.

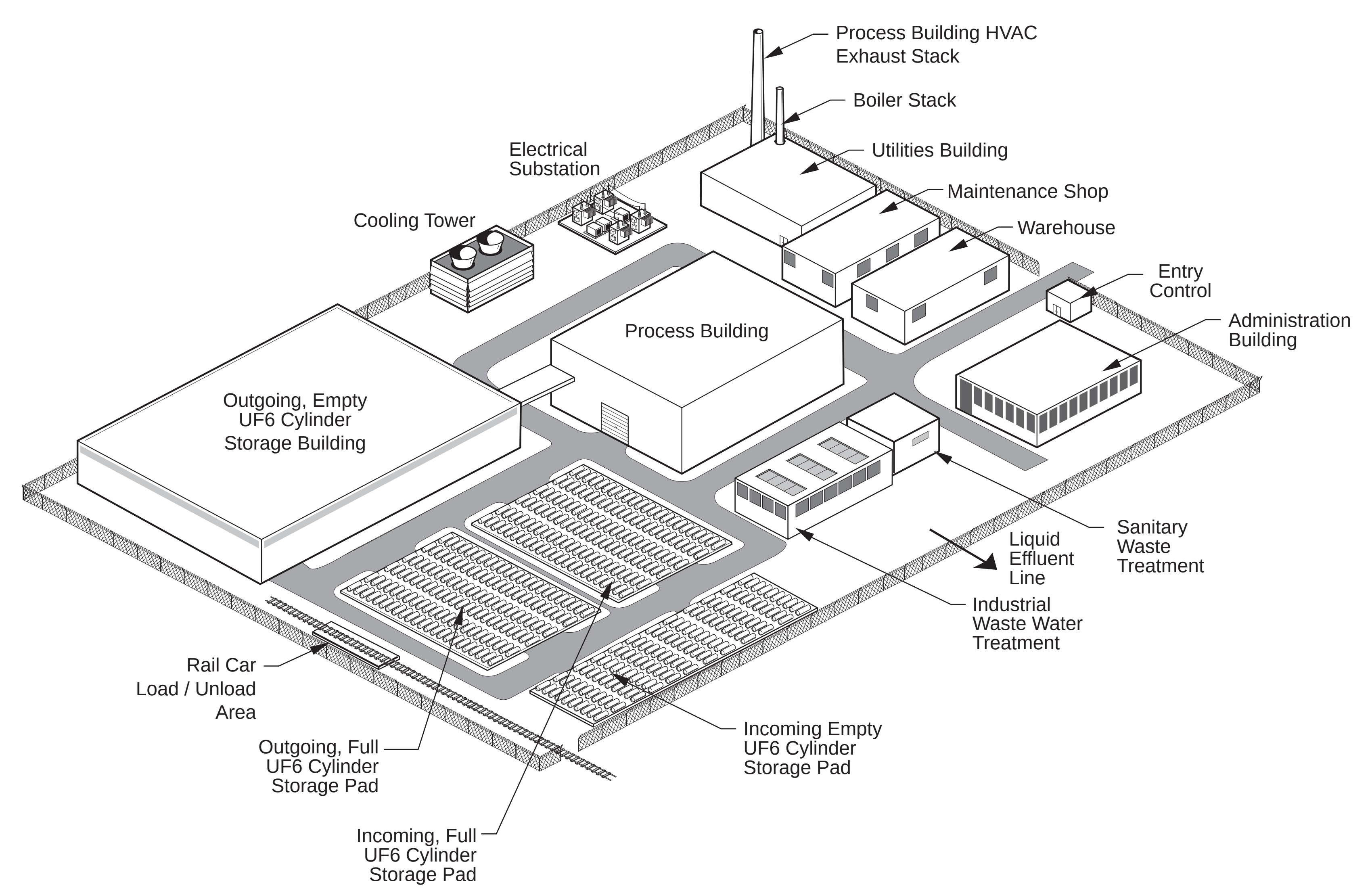

FIGURE E.2 Representative Layout of a Transfer Facility Site (Source: LLNL 1997)

- Impacts were evaluated separately for the three current storage sites, assuming a range in annual processing requirements at each site, because the actual number of cylinders that would not meet DOT requirements at the time of shipment cannot be determined. The ranges of problem cylinders at each site are discussed in the opening section of this appendix. The remaining cylinders were assumed to be standard cylinders that could be shipped directly.

- Cylinder preparation activities would take place over a 20-year period, from 2009 through 2028, for all alternatives except the no action alternative, which does not involve cylinder preparation.

E.3.1 Human Health — Normal Operations

E.3.1.1 Radiological Impacts

Potential radiological impacts for the cylinder preparation options were assessed for involved workers, noninvolved workers, and the general public. Detailed discussions of the methodologies used in the radiological impact analyses are provided in Appendix C and Cheng et al. (1997).

Impacts to involved workers would result primarily from external radiation and would depend only on the number of cylinders handled. The estimated collective doses to involved workers are presented in Figures E.3, E.4, and E.5 for the overcontainer option, cylinder transfer option, and preparation of standard cylinders, respectively. The collective dose is presented as a solid line, with three dashed lines above or below showing the corresponding segments representative for the three cylinder storage sites. Because no airborne or waterborne releases of uranium would be generated for the overcontainer option and preparation of standard cylinders, no radiological impacts would be expected to noninvolved workers or members of the general public. Impacts to these two receptors for the cylinder transfer option are presented in Figures E.6 through E.9. The ranges of impacts for the three cylinder storage sites are different because of the different numbers of cylinder handled and different site characteristics; the ranges are presented by three separate solid lines in the figures.

In general, impacts for the overcontainer option would be less than those for the cylinder transfer option. The average doses to involved workers for all cylinder preparation activities would be less than 660 mrem/yr, which is less than the regulatory limit of 5,000 mrem/yr (10 CFR Part 835). Exposure of noninvolved workers and members of the general public would be extremely small, less than 3.0×10^{-5} mrem/yr.

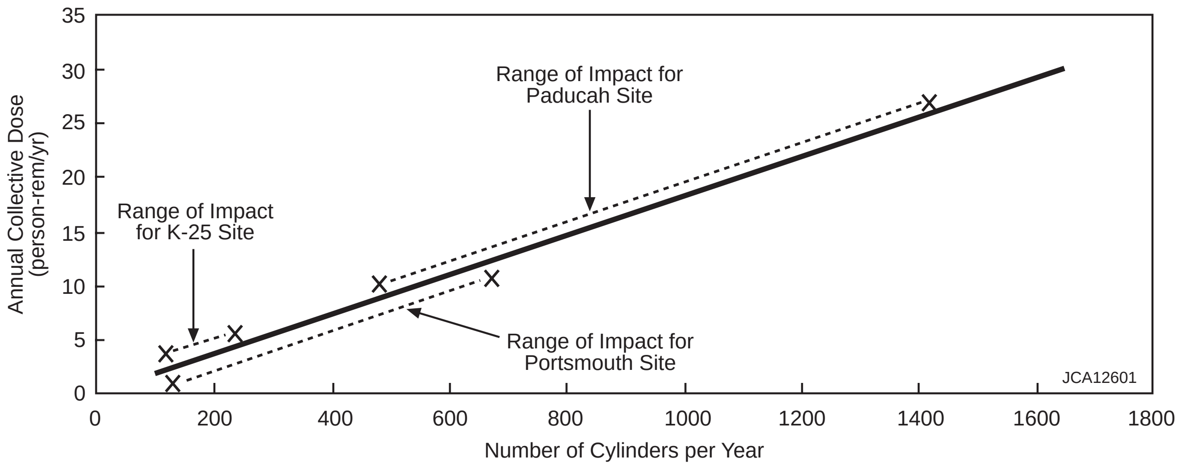

FIGURE E.3 Annual Collective Dose to Involved Workers from Preparing Problem Cylinders for Shipment Using Overcontainers

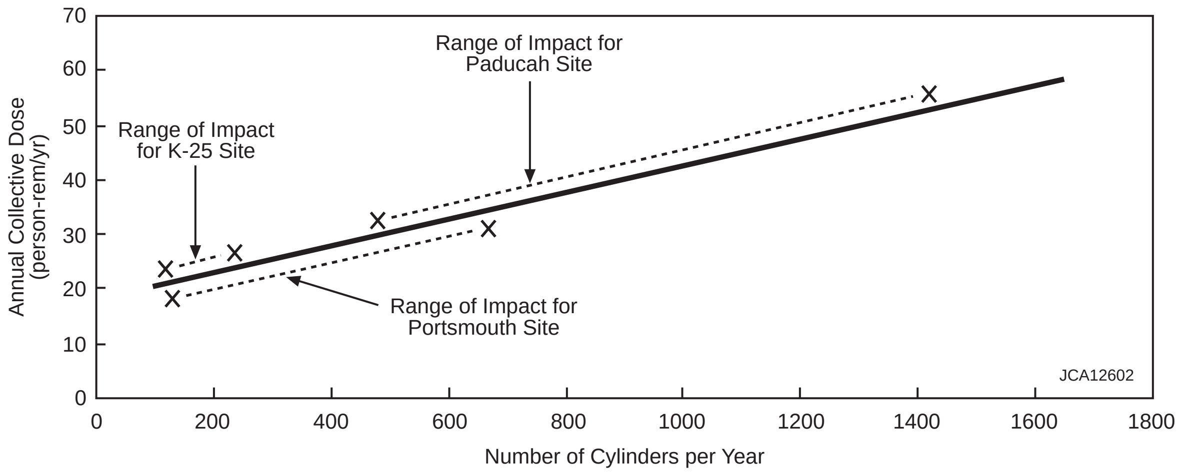

FIGURE E.4 Estimated Annual Collective Dose to Involved Workers from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology

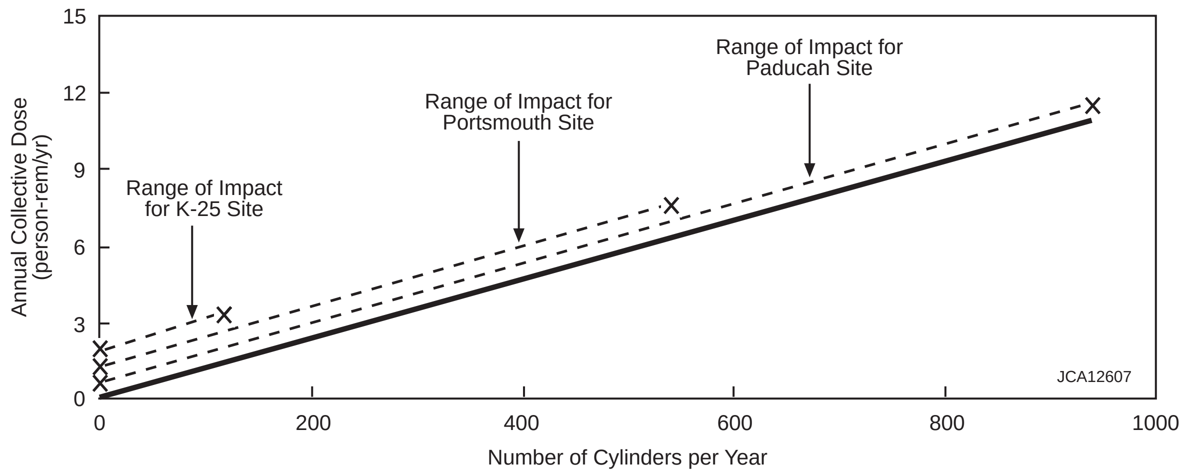

FIGURE E.5 Annual Collective Dose to Involved Workers from Preparing Standard Cylinders for Shipment

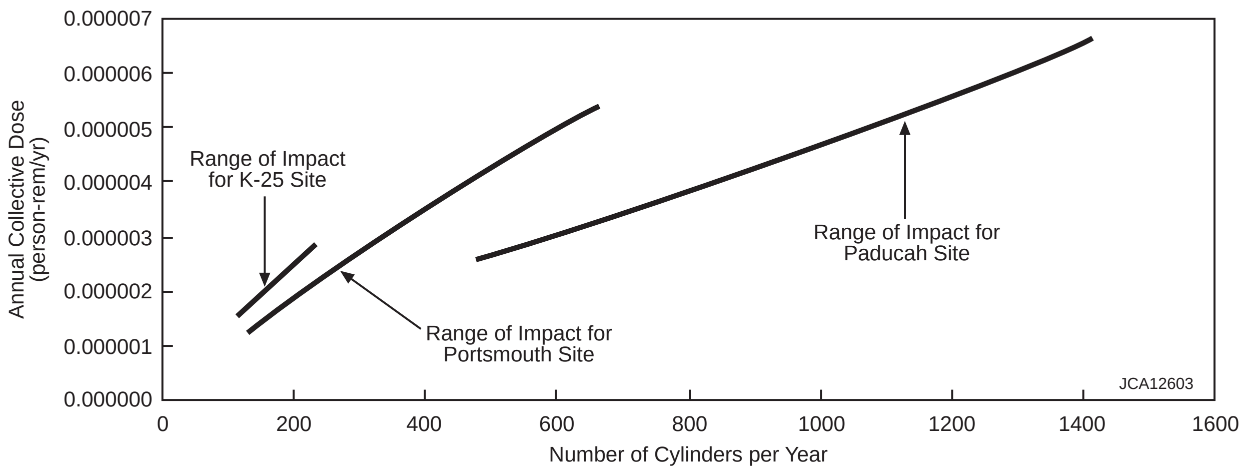

FIGURE E.6 Estimated Annual Collective Dose to Noninvolved Workers from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (population size of noninvolved workers: about 2,000 at Paducah; 2,700 at Portsmouth; and 3,500 at the K-25 Site)

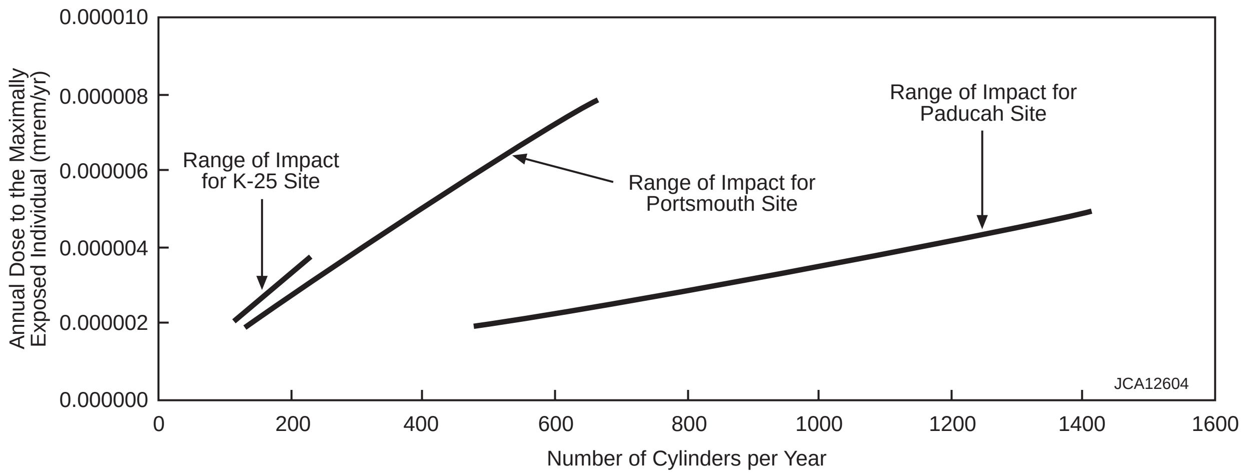

FIGURE E.7 Estimated Annual Dose to the Noninvolved Worker MEI from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology

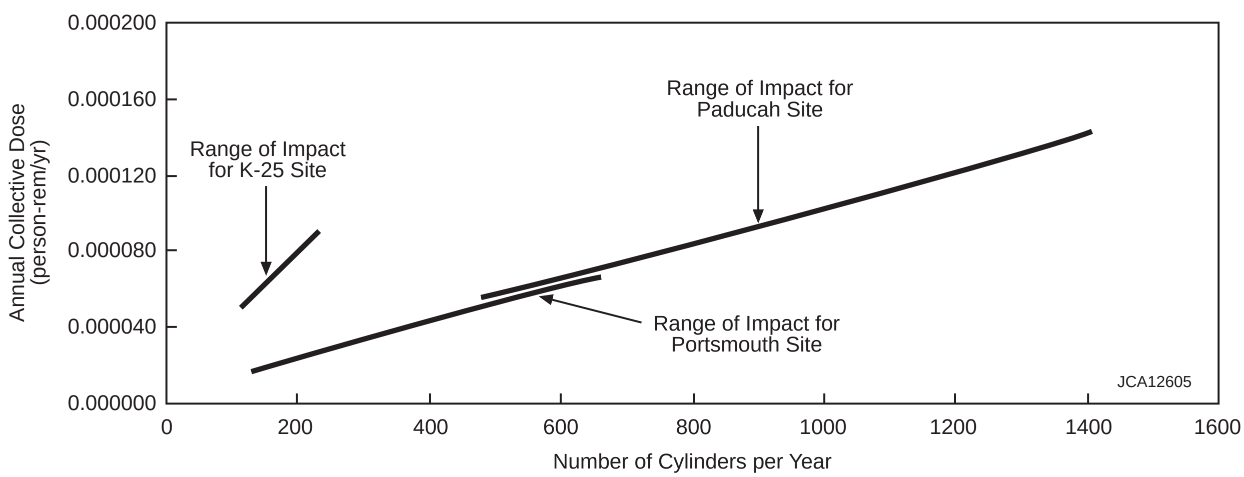

FIGURE E.8 Estimated Annual Collective Dose to the General Public from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (exposure to airborne emissions; population size of general public: about 500,000 at Paducah; 605,000 at Portsmouth; and 877,000 at the K-25 Site)

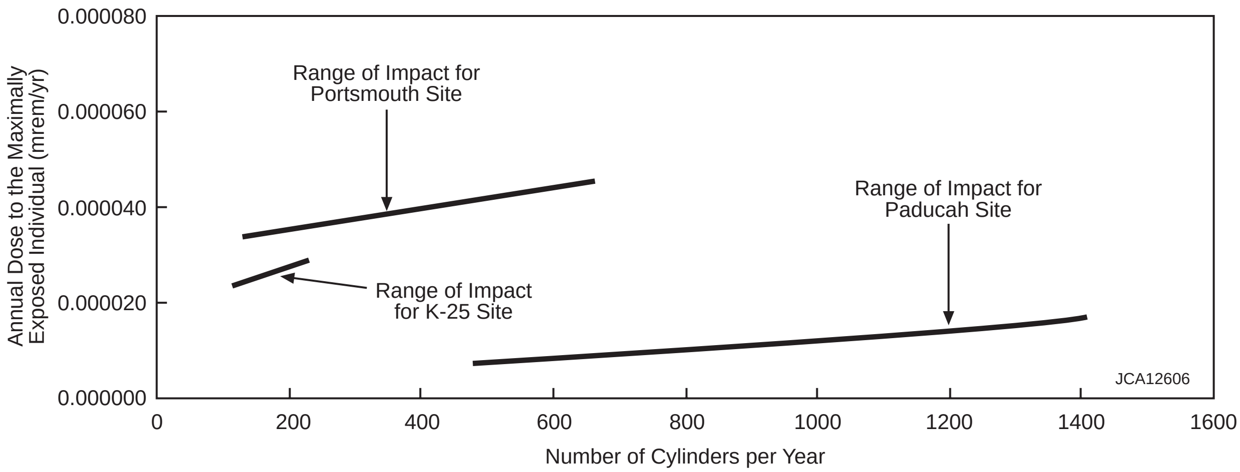

FIGURE E.9 Estimated Annual Dose to the General Public MEI from Preparing Problem Cylinders for Shipment Using the Cylinder Transfer Technology (exposures would result from airborne emissions and discharge of wastewater)

E.3.1.1.1 Overcontainer Option

Potential external radiation exposures of involved workers would occur from preshipment inspection, testing, and surveying of cylinders; unstacking and retrieving cylinders; on-site transportation of cylinders by straddle buggy; loading cylinders into overcontainers placed on trucks or railcars; and packaging cylinders. The annual collective dose to involved workers was estimated to be approximately 2.1 to 4.3 person-rem/yr for about 4 to 8 workers at the K-25 site, 2.4 to 12.2 person-rem/yr for about 5 to 22 workers at the Portsmouth site, and 8.7 to 26 person-rem/yr for about 16 to 47 workers at the Paducah site. Assuming that the workers would work 5 hours per day with an availability factor of 75%, i.e., 3.75 hours per day for cylinder preparation activities (Folga 1996c), the average individual involved worker dose would be approximately 540 mrem/yr. The corresponding average cancer risk would be approximately 0.0002 per year (i.e., an individual's chance of developing a latent fatal cancer would be less than 1 in 5,000 per year).

E.3.1.1.2 Cylinder Transfer Option

The collective dose to involved workers would range from 20 to 24 person-rem/yr for approximately 31 to 42 workers at the K-25 site, 21 to 34 person-rem/yr for approximately 32 to 62 workers at the Portsmouth site, and 30 to 52 person-rem/yr for approximately 52 to 94 workers at the Paducah site. The average individual dose to involved workers would be less than 660 mrem/yr, corresponding to a risk of latent cancer fatality (LCF) of 3×10^{-4} per year (one chance in 3,300 per year).

Radiation doses to noninvolved workers vary from site to site depending on the processing rate of cylinders, site-specific meteorological conditions, and distribution and population of the on-site workers (for collective doses). The estimated radiation dose to the maximally exposed individual (MEI) would be extremely small, less than 8×10^{-6} mrem/yr, due to the small airborne emission rates of uranium. Impacts to the off-site public would also depend on the factors discussed for noninvolved workers, but instead of the distribution and population of the on-site workers, the impacts would be determined by the distribution and population of the off-site public (for collective dose).

The radiation dose to the MEI of the off-site public would be greater than that for the MEI of the noninvolved workers because of the additional exposure from drinking surface water. The radiation dose from drinking surface water would be greater than that from airborne emissions. As a result, the MEI dose for the Paducah site would be less than the doses for the Portsmouth and K-25 sites because surface water around the Paducah site would have the largest dilution capability. The radiation doses to the off-site public MEI from normal operations of the cylinder transfer facility were estimated to be less than 4.4×10^{-5} mrem/yr for all three cylinder storage sites, which is extremely small compared with the regulatory limit of 100 mrem/yr.

E.3.1.1.3 Preparation of Standard Cylinders

The collective radiation exposures to involved workers were estimated to range from 0 to 1.4 person-rem/yr for the K-25 site. The lower range results from the assumption that all the cylinders at the K-25 sites would be problem cylinders. A maximum of four workers would be required for the preparation activities. Radiation doses to involved workers at the Portsmouth site would range from 0 to 6.2 person-rem/yr, with a maximum requirement of 11 workers. At the Paducah site, the collective doses were estimated to range from 0 to 11 person-rem/yr, with a maximum requirement of 18 workers. The average individual dose to involved workers was estimated to be less than 600 mrem/yr for all three cylinder storage sites.

E.3.1.2 Chemical Impacts

The only potential chemical impacts that could be associated with cylinder preparation options would be from exposure to emissions from a cylinder transfer facility; no impacts during normal operations would be expected for the cylinder overcontainer option or preparation of standard cylinders because no releases would occur. Risks from normal operations were quantified on the basis of calculated hazard indices. Information on the exposure assumptions, health effects assumptions, reference doses, and calculational methods used in the chemical impact analysis is provided in Appendix C and Cheng et al. (1997).

During cylinder transfer operations, very small quantities of uranyl fluoride (UO_2F_2) effluent would be discharged into the air and surface water. Estimates of the hazardous chemical human health impacts resulting from cylinder transfer operations were calculated for the range of cylinders that might require processing at each of the three storage sites (i.e., up to 1,420 annually at Paducah, 670 annually at Portsmouth, and 234 annually at K-25). Inhalation of HF was not included in the hazard index calculations because HF emissions from the cylinder transfer facility would be hundreds of times lower than HF emissions from conversion facilities (see Appendix F), for which no chemical impacts were predicted.

No impacts to noninvolved workers or the general public would be expected from normal transfer facility operations. The maximum (high case) hazard indices for chemical impacts to the noninvolved worker MEI working at the cylinder transfer facility would be less than or equal to 3.2×10^{-8}, 3.0×10^{-8}, and 1.1×10^{-8} at the Paducah, Portsmouth, and K-25 sites, respectively. These values are considerably below the threshold for adverse effects (i.e., the ratio of intake to reference dose is much less than 1). The maximum (high case) hazard indices for chemical impacts to the general public MEI would be less than or equal to 2.8×10^{-6}, 6.1×10^{-6}, and 3.6×10^{-6} at the Paducah, Portsmouth, and K-25 sites, respectively; these values are also considerably below the threshold for adverse effects.

E.3.2 Human Health — Accident Conditions

A range of accidents covering the spectrum of high-frequency/low-consequence accidents to low-frequency/high-consequence accidents has been presented in the engineering analysis report (LLNL 1997). These accidents are listed in Table E.4. The results for the radiological and chemical health impacts of the maximum-consequence accident in each frequency category are presented in Sections E.3.2.1 and E.3.2.2. The bounding accidents are the same for both the cylinder overcontainer option and the cylinder transfer option. Results for all accidents listed in Table E.4 are presented in Policastro et al. (1997). Detailed descriptions of the methodology and assumptions used in these calculations are also provided in Appendix C and Policastro et al. (1997).

E.3.2.1 Radiological Impacts

Table E.5 lists the radiological doses to various receptors for the accidents that give the highest dose from each frequency category. The LCF risks for these accidents are given in Table E.6. The doses and the risks are presented as ranges (maximum and minimum) because two different meteorological conditions were considered for each cylinder preparation option (see Appendix C). The doses and risks presented here were obtained by assuming that the accidents would occur. The probability of occurrence for each accident is indicated by the frequency category to which it belongs. For example, accidents in the extremely unlikely category have a probability of occurrence between 1 in 10,000 and 1 in 1 million in any 1 year. The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities would be predicted from any of the accidents.

TABLE E.4 Accidents Considered for the Cylinder Preparation Options

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Cylinder Overcontainers					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, three full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Incredible Accidents (frequency: less than 1 time in 1 million years)					
Small plane crash, two full 48G cylinders[b]	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,190	0 to 30 30 to 121	Ground
Cylinder Transfer					
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the dry ground.	UF_6	24	60 (continuous)	Ground
Cylinder valve shear	A single UF_6 cylinder is mishandled, etc., resulting in shearing of the cylinder valve and loss of solid UF_6 from the valve onto the ground.	UF_6	0.25	120 (continuous)	Ground
UF_6 vapor leak	A UF_6 transfer line leaks 5% of its flowing contents for 10 minutes due to potential compressor or pipe leakage.	UO_2F_2 HF	0.009 2.4	30	Stack
UF_6 liquid leak	A drain line from the UF_6 condensers leaks 5% of its flowing contents due to potential condenser or pipe leakage.	UO_2F_2 HF	0.0045 1.2	30	Stack
Loss of off-site electrical power	Off-site power is lost, which halts facility operations but does not result in significant releases to the environment.	No release	NA	NA	NA
Loss of cooling water	Cooling water flow to the UF_6 condenser is lost, and UF_6 vapor is released.	UO_2F_2 HF	0.009 2.4	2	Stack

TABLE E.4 (Cont.)

Option/Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[a]
Cylinder Transfer (Cont.)					
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area on the wet ground.	HF	96	60 (continuous)	Ground
UF_6 cold trap rupture	A UF_6 cold trap is overfilled with UF_6 and ruptures during heating, releasing UF_6 into the process building.	UO_2F_2 HF	0.13 34	30	Stack
Extremely Unlikely Accidents (frequency: from 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft hole results during handling, with solid UF_6 forming a 4-ft^2 area into a 0.25-in. deep water pool.	HF	150	60 (continuous)	Ground
Vehicle-induced fire, three full 48G cylinders	Three full 48G UF_6 cylinders hydraulically rupture during a fire resulting from the ignition of fuel and/or hydraulic fluid from the transport vehicle, etc.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground
Earthquake	A UF_6 compressor discharge pipe is cleanly sheared during a design-basis earthquake and leaks for 1 minute.	UO_2F_2 HF	0.018 4.7	30	Stack
Tornado	A design-basis tornado does not result in significant releases because UF_6 is a solid at ambient conditions.	No release	NA	NA	NA
Incredible Accidents (frequency: less than 1 in 1 million years)					
Flood	The facility would be located at a site that would preclude flooding.	No release	NA	NA	NA
Small plane crash, two full 48G cylinders[b]	A small plane crash affects two full 48G UF_6 cylinders. One cylinder hydraulically ruptures during a fire resulting from the ignition of aviation fuel.	UF_6	0 3,840 2,980 1,190	0 to 12 12 12 to 30 30 to 121	Ground
	The second cylinder is initially breached due to impact with aircraft debris, followed by sublimation due to fire.	UF_6	4,240 1,192	0 to 30 30 to 121.4	Ground

[a] Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

[b] The frequency range of a small plane crash would be a function of site: extremely unlikely for the Paducah site, and incredible for the Portsmouth and K-25 sites.

TABLE E.5 Estimated Radiological Doses per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options

		Maximum Dose[c]				Minimum Dose[c]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Site/Accident[a]	Frequency Category[b]	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population (person-rem)
Paducah Site									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.4	2.3×10^{-3}	2.6×10^{-1}	3.3×10^{-3}	6.3×10^{-2}	9.8×10^{-5}	3.0×10^{-2}
UF_6 cold trap rupture[d]	U	1.0×10^{-7}	1.5×10^{-4}	1.1×10^{-7}	5.6×10^{-4}	2.1×10^{-8}	2.8×10^{-5}	8.6×10^{-8}	2.3×10^{-4}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.5×10^{1}	1.5×10^{-2}	2.8×10^{1}	3.7×10^{-3}	1.3	1.9×10^{-3}	1.1
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	4.9	4.9×10^{-3}	3.7×10^{-1}	8.7×10^{-4}	6.4×10^{-1}	6.2×10^{-4}	5.2×10^{-2}
Portsmouth Site									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	2.2	2.2×10^{-3}	2.1×10^{-1}	3.3×10^{-3}	9.5×10^{-2}	9.3×10^{-5}	2.8×10^{-2}
UF_6 cold trap rupture[d]	U	1.0×10^{-7}	1.5×10^{-4}	1.1×10^{-7}	7.1×10^{-4}	2.1×10^{-8}	1.5×10^{-5}	8.6×10^{-8}	2.5×10^{-4}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.6×10^{1}	1.3×10^{-2}	3.2×10^{1}	3.7×10^{-3}	2.0	1.9×10^{-3}	1.6
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	5.3	4.3×10^{-3}	5.5×10^{-1}	8.7×10^{-4}	6.9×10^{-1}	6.2×10^{-4}	7.6×10^{-2}
K-25 Site									
Corroded cylinder spill, dry conditions	L	7.7×10^{-2}	1.3	2.7×10^{-3}	4.3×10^{-1}	3.3×10^{-3}	6.0×10^{-2}	1.1×10^{-4}	5.9×10^{-2}
UF_6 cold trap rupture[d]	U	1.0×10^{-7}	1.8×10^{-4}	1.1×10^{-7}	1.2×10^{-3}	2.1×10^{-8}	3.6×10^{-5}	8.6×10^{-8}	5.0×10^{-4}
Vehicle-induced fire, 3 full 48G cylinders	EU	2.0×10^{-2}	1.6×10^{1}	1.3×10^{-2}	6.3×10^{1}	3.7×10^{-3}	2.4	1.9×10^{-3}	2.2
Small plane crash, 2 full 48G cylinders	I	6.6×10^{-3}	5.4	4.3×10^{-3}	7.4×10^{-1}	8.7×10^{-4}	6.9×10^{-1}	7.1×10^{-4}	1.0×10^{-1}

[a] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[b] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[c] Maximum and minimum doses reflect differences in assumed meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum doses would occur under D stability with 4 m/s wind speed.

[d] Applicable only to the cylinder transfer option.

TABLE E.6 Estimated Radiological Health Risks per Accident Occurrence for the Cylinder Overcontainer and Cylinder Transfer Options[a]

Site/Accident[b]	Frequency Category[c]	Maximum Risk[d] (LCFs)				Minimum Risk[d] (LCFs)			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
		MEI	Population	MEI	Population	MEI	Population	MEI	Population
Paducah Site									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	6×10^{-4}	1×10^{-6}	1×10^{-4}	1×10^{-6}	3×10^{-5}	5×10^{-8}	1×10^{-5}
UF_6 cold trap rupture[e]	U	4×10^{-11}	6×10^{-8}	4×10^{-11}	3×10^{-7}	8×10^{-12}	1×10^{-8}	4×10^{-11}	1×10^{-7}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	1×10^{-2}	1×10^{-6}	5×10^{-4}	1×10^{-6}	5×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	2×10^{-4}	3×10^{-7}	3×10^{-4}	3×10^{-7}	3×10^{-5}
Portsmouth Site									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	9×10^{-4}	1×10^{-6}	1×10^{-4}	1×10^{-6}	4×10^{-5}	5×10^{-8}	1×10^{-5}
UF_6 cold trap rupture[e]	U	4×10^{-11}	6×10^{-8}	6×10^{-11}	4×10^{-7}	8×10^{-12}	6×10^{-9}	4×10^{-11}	1×10^{-7}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	6×10^{-6}	2×10^{-2}	1×10^{-6}	8×10^{-4}	1×10^{-6}	8×10^{-4}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	3×10^{-4}	3×10^{-7}	3×10^{-4}	3×10^{-7}	4×10^{-5}
K-25 Site									
Corroded cylinder spill, dry conditions	L	3×10^{-5}	5×10^{-4}	1×10^{-6}	2×10^{-4}	1×10^{-6}	2×10^{-5}	6×10^{-8}	3×10^{-5}
UF_6 cold trap rupture[e]	U	4×10^{-11}	7×10^{-8}	6×10^{-11}	6×10^{-7}	8×10^{-12}	1×10^{-8}	4×10^{-11}	3×10^{-7}
Vehicle-induced fire, 3 full 48G cylinders	EU	8×10^{-6}	6×10^{-3}	7×10^{-6}	3×10^{-2}	1×10^{-6}	9×10^{-4}	1×10^{-6}	1×10^{-3}
Small plane crash, 2 full 48G cylinders	I	3×10^{-6}	2×10^{-3}	2×10^{-6}	4×10^{-4}	3×10^{-7}	3×10^{-4}	4×10^{-7}	5×10^{-5}

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCF) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.0001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest risk to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} - 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} - 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect differences in assumed meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] Applicable only to the cylinder transfer option.

- The maximum radiological dose to noninvolved worker and general public MEIs (assuming an accident occurred) would be 0.077 rem. This dose is less than the 25-rem dose recommended for assessing the adequacy of protection of public health and safety from potential accidents by the U.S. Nuclear Regulatory Commission (NRC 1994).

- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table E.6] by the annual probability of occurrence by the number of years of operation) would be less than 1 for all of the accidents.

E.3.2.2 Chemical Impacts

The accidents considered for the cylinder preparation options are listed in Table E.4. The results of the accident consequence modeling for chemical impacts are given in Tables E.7 and E.8. The results are presented as the (1) number of persons with potential for adverse effects and (2) the number of persons with potential for irreversible adverse effects. The results are given for the accident within each accident frequency category that would affect the largest number of persons (total of workers and off-site population) (Policastro et al. 1997). The impacts presented here are based on the assumption that the accidents would occur. The accidents listed in Tables E.7 and E.8 are not identical because an accident with the largest impacts for adverse effects might not lead to the largest impacts for irreversible adverse effects. The following general conclusions may be drawn from the chemical accident assessment:

- If the accidents identified in Table E.7 and E.8 did occur, the number of persons in the off-site population with potential for adverse effects would range from 0 to 1,900 (maximum corresponding to the vehicle-induced fire scenario at the Paducah site), and the number of off-site persons with potential for irreversible adverse effects would range from 0 to 1 (maximum corresponding to the corroded cylinder spill with pooling scenario at the Portsmouth site).

- If the accidents identified in Tables E.7 and E.8 did occur, the number of noninvolved workers with potential for adverse effects would range from 0 to 1,000 (maximum corresponding to the vehicle-induced fire scenario at the Portsmouth site), and the number of noninvolved workers with potential for irreversible adverse effects would range from 0 to 300 (maximum corresponding to the corroded cylinder spill with pooling scenario at the Paducah site).

TABLE E.7 Number of Persons with Potential for Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options[a]

		Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Site/Accident[b]	Frequency Category[c]	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Paducah Site									
Corroded cylinder spill, dry conditions	L	Yes	10	No	0	Yes[f]	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	690	Yes	14	Yes	7	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	910	Yes	1,900	Yes	4	Yes	3
Small plane crash, 2 full 48G cylinders	I	Yes	67	Yes	18	Yes[f]	0	No	0
Portsmouth Site									
Corroded cylinder spill, dry conditions	L	Yes	48	Yes[f]	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	850	Yes	12	Yes	2	Yes[f]	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	1,000	Yes	650	Yes	160	Yes	4
Small plane crash, 2 full 48G cylinders	I	Yes	700	Yes	22	No	0	No	0
K-25 Site									
Corroded cylinder spill, dry conditions	L	Yes	69	No	0	Yes[f]	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	700	Yes	18	Yes	47	No	0
Vehicle-induced fire, 3 full 48G cylinders	EU	Yes	770	Yes	550	No	0	Yes	12
Small plane crash, 2 full 48G cylinders	I	Yes	420	Yes	34	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site people) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations ($10^{-2} – 10^{-4}$/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} – 10^{-6}$/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

TABLE E.8 Number of Persons with Potential for Irreversible Adverse Effects from Accidents under the Cylinder Overcontainer and Cylinder Transfer Options[a]

		Maximum Number of Persons[d]				Minimum Number of Persons[d]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Site/Accident[b]	Frequency Category[c]	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population	MEI[e]	Population
Paducah Site									
Corroded cylinder spill, dry conditions[f]	L	Yes[g]	0	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	130	Yes[g]	0	Yes	1	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	300	Yes	1	Yes	1	No	0
Small plane crash, 2 full 48G cylinders	I	No	0	No	0	No	0	No	0
Portsmouth Site									
Corroded cylinder spill, dry conditions	L	Yes[g]	0	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	90	Yes	1	Yes[g]	0	No	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	110	Yes	1	Yes[g]	0	No	0
Small plane crash, 2 full 48G cylinders[f]	I	No	0	No	0	No	0	No	0
K-25 Site									
Corroded cylinder spill, dry conditions	L	Yes	3	No	0	No	0	No	0
Corroded cylinder spill, wet conditions – rain	U	Yes	140	Yes	0	Yes	2	No	0
Vehicle-induced fire, 3 full 48G cylinders[f]	EU	No	0	No	0	No	0	No	0
Small plane crash, 2 full 48G cylinders[f]	I	No	0	No	0	No	0	No	0

[a] Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency times 20 years of operations. The estimated frequencies are as follows: likely (L), 0.1; unlikely (U), 0.001; extremely unlikely (EU), 0.00001; incredible (I), 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); unlikely (U), estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} – 10^{-4}/yr); extremely unlikely (EU), estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} – 10^{-6}/yr); incredible (I), estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[d] Maximum and minimum risks reflect different meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with 1 m/s wind speed, whereas minimum risks would occur under D stability with 4 m/s wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential irreversible adverse effects to an individual.

[f] These accidents would result in the largest plume size for the frequency category, although no people would be affected.

[g] MEI locations were evaluated at 100 m from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the actual worker and general public population distributions were used, which did not show receptors at the MEI locations.

- Accidents resulting in a vehicle-induced fire involving three 48G cylinders during very stable (nighttime) meteorological conditions would have a very low probability of occurrence but could affect a large number of people.

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (per year) times the number of years of operations (20 years, 2009-2028). The results indicate that the maximum risk values would be less than 1 for all accidents, except the following:

  - *Potential Adverse Effects and Irreversible Adverse Effects:*

    Corroded cylinder spill, dry conditions (L, likely):
    Workers at the Paducah, Portsmouth, and K-25 sites

    Corroded cylinder spill, wet conditions – rain (U, unlikely):
    Workers at the Paducah, Portsmouth, and K-25 sites

  These risk values are conservative because the numbers of people affected were based on assuming (1) meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and 1 m/s wind speed) and (2) wind in the direction that would lead to maximum numbers of individuals exposed for workers or for the general population.

To aid in the interpretation of accident analysis results, the number of fatalities potentially associated with the estimated potential irreversible effects was estimated. All the bounding-case accidents shown in Table E.8 would involve releases of UF_6 and potential exposure to HF and uranium compounds. These exposures could be high enough to result in death for up to 1% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). This would mean that for workers experiencing a range of 0 to 300 irreversible adverse effects, approximately 0 to 3 deaths would be expected. Similarly, of the general public experiencing a range of 0 to 1 irreversible adverse effects, less than 1 death would be expected. These are the maximum potential consequences of the accidents; the upper ends of the ranges result from the assumption of worst-case weather conditions, with the wind blowing in the direction where the highest number of people would be exposed.

E.3.2.3 Physical Hazards

The risk of on-the-job fatalities and injuries for involved and noninvolved workers is calculated using industry-specific statistics from the Bureau of Labor Statistics, as reported by the National Safety Council (1995). Construction and manufacturing annual fatality and injury rates were used respectively for the construction and operational phases of the cylinder transfer facility lifetime; manufacturing fatality and injury rates were used for standard cylinder shipping preparation and overcontainer activities.

Figure E.10 shows the fatality and injury incidences for all workers associated with packaging cylinders in overcontainers across the ranges that might be required at the three current storage sites (i.e., ranges of 480 to 1,420 cylinders/yr at the Paducah site; 130 to 670 cylinders/yr at the Portsmouth site; and 120 to 234 cylinders/yr at the K-25 site). The impacts would increase directly as a function of the numbers of cylinders placed in overcontainers annually. Fatality incidences over the 20-year period of operations would all be less than 1 — ranging from about 0.029 to 0.087 at Paducah, about 0.007 to 0.041 at Portsmouth, and about 0.007 to 0.014 at K-25. On the basis of the ranges given for overcontainer requirements, the corresponding estimated injury incidence over the 20-year operations period would be from about 39 to 115 at Paducah, about 10 to 54 at Portsmouth, and about 9 to 18 at K-25.

Figures E.11 and E.12 give the fatality and injury incidences for all workers associated with transferring cylinder contents to new cylinders across the same potential range requirements as discussed above. It was assumed that any transfer facility would be constructed with a capacity near to or somewhat greater than the maximum number of cylinders expected to require processing (the actual numbers would not be determined until the time of cylinder shipment). Thus, the fatality and injury incidence estimates for construction of the transfer facility remain constant for each site across the range of annual cylinder processing requirements. However, data in the engineering analysis report (LLNL 1997) also showed that the relationship between number of cylinders processed annually and number of employees required per cylinder processed would not increase linearly. For example, more employees per cylinder would be required to process 100 cylinders than to process 1,000 cylinders. Therefore, the fatality and injury incidences would be lower at the K-25 and Portsmouth sites than at the Paducah site because of lower processing requirements; however, the fatality and injury incidences would also increase much more rapidly over the range processed annually at these sites, whereas the estimates for the Paducah site would remain relatively constant. Once the processing rate was above about 500 cylinders per year, fatality and injury incidences

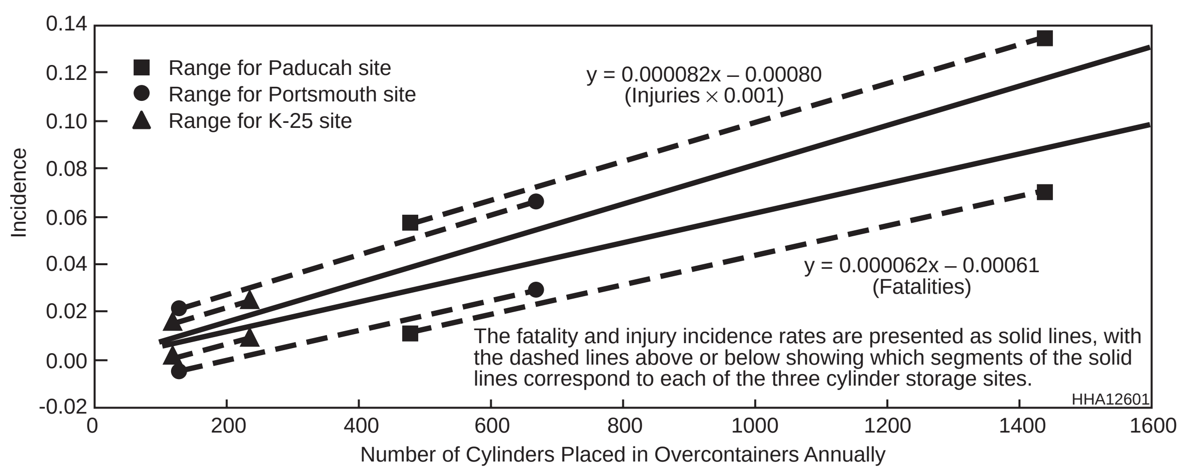

FIGURE E.10 Worker Fatality and Injury Incidence for Cylinder Overcontainer Activities

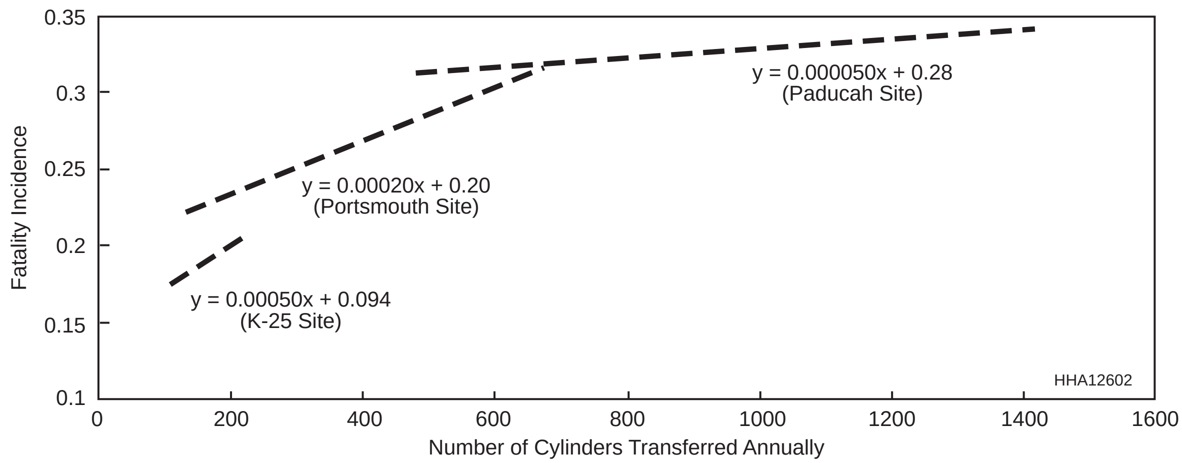

FIGURE E.11 Worker Fatality Incidence for Cylinder Transfer Activities

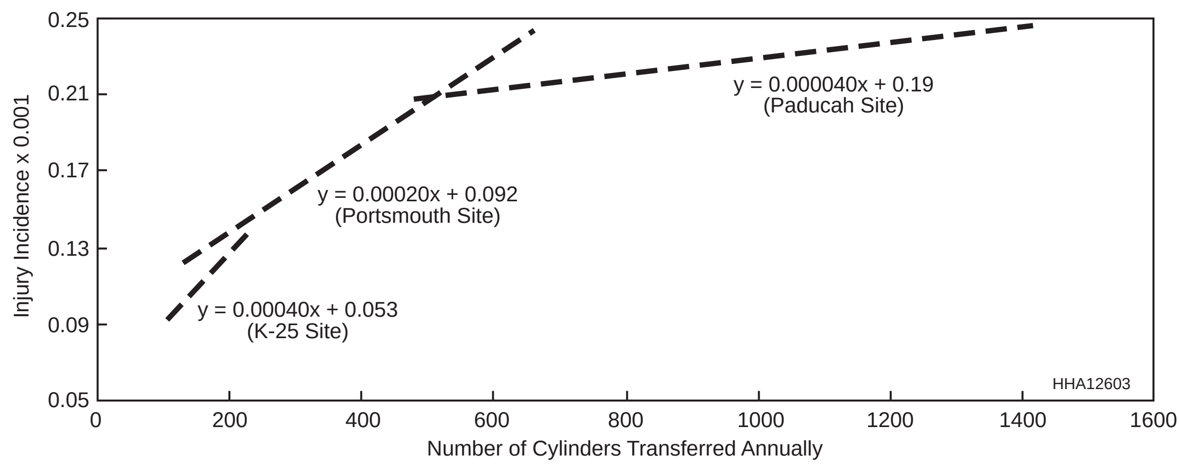

FIGURE E.12 Worker Injury Incidence for Cylinder Transfer Activities

would increase very little up to the maximum rate examined of about 1,600 cylinders per year. Fatality incidences for transfer facility construction and operation would all be less than 1, ranging from about 0.31 to 0.34 at Paducah, about 0.22 to 0.31 at Portsmouth and about 0.17 to 0.21 at K-25. On the basis of the assumed range in cylinder transfer requirements given above, the corresponding injury incidence would range from about 210 to 250 at Paducah, about 110 to 240 at Portsmouth, and about 94 to 140 at K-25.

Figure E.13 gives the fatality and injury incidences for all workers associated with preparation of standard cylinders for transport across the ranges that might be required at the three current storage sites (i.e., ranges from 0 to 940 cylinders/yr at Paducah, 0 to 540 cylinders/yr at Portsmouth, and 0 to 120 cylinders/yr at K-25). The impacts would increase directly as a function of the numbers of cylinders prepared annually. Fatality incidences would all be less than 1, ranging from 0 to about 0.043 at Paducah, 0 to about 0.025 at Portsmouth, and 0 to about 0.006 at K-25. The corresponding injury incidence would range from 0 to about 87 at Paducah, 0 to about 33 at Portsmouth, and 0 to about 7 at K-25.

E.3.3 Air Quality

Air quality impacts would result from the emissions associated with two distinct cylinder preparation options: (1) movement of cylinders in preparation for transportation, both those cylinders requiring overcontainers and standard cylinders, and (2) construction and operation of facilities to transfer contents from substandard cylinders to new ones. These two options are referred to in the following discussion as “overcontainer” and “transfer facility.” No construction would be required for the overcontainer option. Descriptions of the methodology and assumptions are provided in Appendix C and Tschanz (1997).

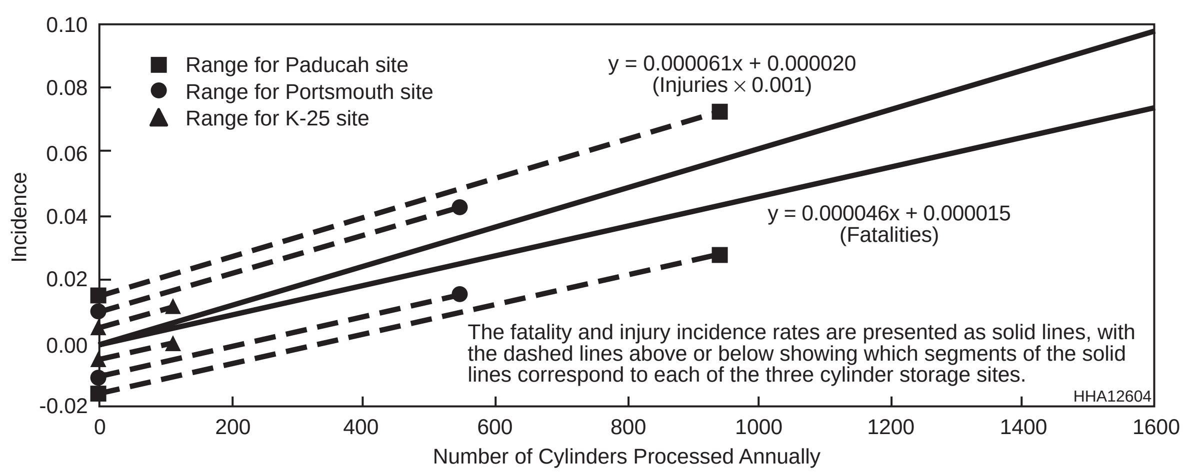

FIGURE E.13 Worker Fatality and Injury Incidence for Standard Cylinder Preparation

E.3.3.1 Paducah Site

Potential air quality impacts for carbon monoxide (CO), nitrogen oxides (NO_x), and PM_{10} (particulate matter with a mean diameter of 10 µm or less) from implementation of the overcontainer and transfer facility options at the Paducah site are presented in Table E.9. Ranges of impacts for the overcontainer option represent the assumptions of low to high numbers of cylinders that might be substandard at the time of transportation. All of the impacts for the overcontainer option would be negligible.

Construction of a transfer facility with a capacity to handle 1,600 cylinders per year would cause larger impacts than operation of the facility. The construction impacts would all be less than the applicable air quality standards. The largest impact, 62% of the standard, would occur for the 24-hour PM_{10} concentration (Table E.9). The PM_{10} concentrations would occur primarily as a result of fugitive dust from land disturbance. The estimated fugitive dust emissions from construction activities were based on a general emission factor that considers only the size of the disturbed area and, therefore, might be overestimated relative to the actual use of construction equipment. Mitigative measures, such as spraying water, would be expected to reduce the PM_{10} concentrations. More detailed information about the construction activities would be required to accurately assess the likely actual impacts.

Criteria pollutant concentrations during operations would be less than 2% of the values estimated to occur during construction, making all impacts negligible. Process stack emissions during operations would produce an annual average HF concentration of 3.1×10^{-5} µg/m^3 and UO_2F_2 concentration of 2.1×10^{-6} µg/m^3.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the Paducah site. McCracken County in the Paducah-Cairo Interstate Air Quality Control Region is currently in attainment for all criteria pollutant standards, including ozone. The pollutants most related to ozone formation that could result from the cylinder preparation options at the Paducah site would be hydrocarbons (HC) and NO_x. The potential effects on ozone of those emissions can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in McCracken County, as recorded in the Kentucky Division of Air Quality Control "Emissions Inventory" for 1995 (Hogan 1996). The estimated HC and NO_x emissions of 0.20 and 2.19 tons/yr during operation of the cylinder transfer facility would be only 0.034 and 0.006%, respectively, of the 1995 McCracken County emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the county. Emissions of HC and NO_x from the overcontainer option would be even smaller.

TABLE E.9 Air Quality Impacts of Cylinder Preparation Options at the Paducah Site

	Estimated Maximum Pollutant Concentrations from the Overcontainer Option							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]
CO	23 – 31	0.00078	3.0 – 4.0	0.00040	1.2 – 1.6	–	0.048 – 0.063	–
NO_x	3.5 – 4.7	–	0.46– 0.62	–	0.18 – 0.24	–	0.0073 – 0.0098	0.000098
PM_{10}	0.69 – 0.93	–	0.091 – 0.12	–	0.036 – 0.048	0.00032	0.0014 – 0.0019	0.000038

	Estimated Pollutant Concentrations from Construction of the Cylinder Transfer Facility							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]
CO	3,200	0.080	1,400	0.14	540	–	50	–
NO_x	450	–	200	–	77	–	7.2	0.072
PM_{10}	550	–	250	–	93	0.62	8.7	0.17

[a] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded. A hyphen indicates that no standard is available for this averaging period.

E.3.3.2 Portsmouth Site

The air quality impacts of cylinder preparation options at the Portsmouth site are shown in Table E.10. All impacts from construction of a transfer facility with a capacity for 960 cylinders per year at the Portsmouth site would be less than applicable air quality standards.

The impacts of criteria pollutant emissions during operation of the transfer facility would be negligible. Process stack emissions during operations would produce an annual average HF concentration of 1.9×10^{-5} µg/m^3 and UO_2F_2 concentration of 1.5×10^{-6} µg/m^3.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the Portsmouth site. Pike and Scioto Counties in the Wilmington-Chillicothe-Logan Air Quality Control Region are currently in attainment for all criteria pollutant standards, including ozone. The pollutant emissions most related to ozone formation that could result from the cylinder preparation options at the Portsmouth site would be HC and NO_x. The potential effects on ozone of those emissions can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in Pike and Scioto Counties, as recorded in the Ohio Environmental Protection Agency "Emissions Inventory" for 1990 (Juris 1996). The estimated HC and NO_x emissions of 0.18 and 1.65 tons/yr from operation of the cylinder transfer facility would be only 0.011 and 0.069%, respectively, of the 1990 two-county emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region. Emissions of HC and NO_x from the overcontainer option would be even smaller.

E.3.3.3 K-25 Site

The air quality impacts of cylinder preparation options at the K-25 site are shown in Table E.11. The NO_x and PM_{10} impacts from construction of a transfer facility with a capacity for 320 cylinders per year at the K-25 site would be larger in comparison with applicable air quality standards than would the impacts from a 1,600/yr cylinder transfer facility at the Paducah site. In part, this would be due to the fact that construction emissions would not decrease in proportion to the reduction in transfer capacity. Emissions of PM_{10} were assumed to be the same at all three sites.

The impacts of criteria pollutant emissions during operation of the transfer facility would be negligible. Process stack emissions during operations would produce an annual average HF concentration of 1.3×10^{-5} µg/m^3 and UO_2F_2 concentration of 1.0×10^{-6} µg/m^3.

No quantitative estimate was made of the impacts on the criterion pollutant ozone. Ozone formation is a regional issue affected by emissions data for the entire area around the K-25 site. Anderson and Roane Counties in the Eastern Tennessee-Southwestern Virginia Interstate Air Quality Control Region are currently in attainment for all criteria pollutant standards, including ozone. The pollutant emissions most related to ozone formation that could result from the cylinder preparation

TABLE E.10 Air Quality Impacts of Cylinder Preparation Options at the Portsmouth Site

Pollutant	Estimated Maximum Pollutant Concentrations from the Overcontainer Option							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range (μg/m^3)	Fraction of Standard[a]	Range (μg/m^3)	Fraction of Standard[a]	Range (μg/m^3)	Fraction of Standard[a]	Range (μg/m^3)	Fraction of Standard[a]
CO	5.4 – 7.7	0.00019	0.91 – 1.3	0.00013	0.36 – 0.52	–	0.029 – 0.042	–
NO_x	0.81 – 1.2	–	0.14– 0.20	–	0.054– 0.079	–	0.0044 – 0.0064	0.000064
PM_{10}	0.16 – 0.23	–	0.027 – 0.040	–	0.011 – 0.016	0.00011	0.00088 – 0.0013	0.000026

Pollutant	Estimated Pollutant Concentrations from Construction of the Cylinder Transfer Facility							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Concentration (μg/m^3)	Fraction of Standard[a]	Concentration (μg/m^3)	Fraction of Standard[a]	Concentration (μg/m^3)	Fraction of Standard[a]	Concentration (μg/m^3)	Fraction of Standard[a]
CO	2,600	0.065	660	0.066	250	–	29	–
NO_x	390	–	97	–	38	–	4.3	0.043
PM_{10}	560	–	140	–	54	0.36	6.2	0.12

[a] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded. A hyphen indicates that no standard is available for this averaging period.

TABLE E.11 Air Quality Impacts of Cylinder Preparation Options at the K-25 Site

Pollutant	Estimated Maximum Pollutant Concentrations from the Overcontainer Option							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]	Range ($\mu g/m^3$)	Fraction of Standard[a]
CO	3.6 – 4.5	0.00011	0.54 – 0.67	0.00007	0.23 – 0.29	–	0.017 – 0.021	–
NO_x	0.56 – 0.70	–	0.083– 0.10	–	0.036– 0.044	–	0.0026 – 0.0033	0.00003
PM_{10}	0.11 – 0.14	–	0.016 – 0.020	–	0.0071 – 0.0088	0.00006	0.00052 – 0.00064	0.00001
	Estimated Pollutant Concentrations from Construction of the Cylinder Transfer Facility							
	1-Hour Average		8-Hour Average		24-Hour Average		Annual Average	
Pollutant	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]	Concentration ($\mu g/m^3$)	Fraction of Standard[a]
CO	2,200	0.055	1,100	0.11	470	–	61	–
NO_x	320	–	160	–	69	–	8.9	0.089
PM_{10}	590	–	300	–	130	0.87	16	0.32

[a] Ratio of the upper end of the concentration range divided by the respective air quality standard. A ratio of less than 1 indicates that the standard would not be exceeded. A hyphen indicates that no standard is available for this averaging period.

options at the K-25 site would be HC and NO_x. The potential effects on ozone of those pollutants can be put in perspective by comparing them with the total emissions of HC and NO_x for point sources in Anderson and Roane Counties, as recorded in the Tennessee Division of Air Pollution Control "Emissions Inventory" for 1995 (Conley 1996). The estimated HC and NO_x emissions of 0.14 and 1.20 tons/yr during operation of the cylinder transfer facility would be only 0.005 and 0.002%, respectively, of the 1995 two-county emissions totals of those pollutants from inventoried point sources. These small additional contributions to the totals would be unlikely to alter the ozone attainment status of the region. Emissions of HC and NO_x from the overcontainer option would be even smaller.

E.3.4 Water and Soil

The cylinder preparation options were assessed for potential impacts on surface water, groundwater, and soils. Details on the methodology and assumptions are presented in Appendix C and Tomasko (1997).

E.3.4.1 Surface Water

Potential impacts to surface water for the cylinder preparation options could occur during construction, normal operations, and postulated accident scenarios. For the cylinder overcontainer option and preparation of standard cylinders, however, there would be no impacts to surface water because no liquid wastes would be produced during construction and operations (LLNL 1997) and no accident scenarios were identified in the engineering analysis report that would directly release contaminated material to surface water (LLNL 1997). Secondary impacts to surface water would also be negligible because of the small concentrations associated with air deposition.

For the cylinder transfer facility, potential impacts to surface water during construction, normal operations, and accident scenarios would include changes in runoff, changes in quality, and floodplain encroachment.

E.3.4.1.1 Construction

Paducah Site. Construction of a cylinder transfer facility with a capacity for 1,600 cylinders per year at the Paducah site would increase runoff because about 15 acres (6.1 ha) of land would be replaced with paved lots and buildings (Table E.12). This increase in impermeable surface would produce a negligible impact on runoff because of the size of the existing watershed (0.4% of the land available).

TABLE E.12 Summary of Environmental Parameters for the Cylinder Transfer Facility

		Requirements per Site		
Option	Unit	Paducah	Portsmouth	K-25
Disturbed land area	acres	21	14	12
Paved area	acres	15	10	8
Construction water	million gal/yr	10	8	6.5
Construction wastewater	million gal/yr	5	4	3.3
Operations water	million gal/yr	9	7	6
Operations wastewater	million gal/yr	7.1	5.7	4.4
Radioactive release	Ci/yr	0.00078	0.00063	0.00049

Construction of the cylinder transfer facility would require about 10 million gal/yr (19 gpm) of water. This withdrawal would correspond to less than 0.000016% of average river flow and would produce a negligible impact on water levels and floodplains. During construction, the quality of nearby surface water could be affected by releases of wastewater containing small quantities of contaminants such as construction chemicals, organics, and suspended solids. About 5 million gal/yr (9.5 gpm) of construction wastewater would be discharged to nearby surface waters or to an appropriate wastewater sewer under a National Pollutant Discharge Elimination System (NPDES) permit. Once released, the wastewater would eventually be discharged to the Ohio River, resulting in dilution in excess of 12 million:1. All contaminant concentrations would be considerably below regulatory standards.

Portsmouth Site. Construction of a cylinder transfer facility with a capacity of 960 cylinders per year at the Portsmouth site would increase runoff because about 10 acres (4.1 ha) of land would be replaced with paved lots and buildings (Table E.12). This increase in impermeable surface would produce a negligible impact on runoff because of the size of the existing watershed (0.3% of the land available).

Construction of the cylinder transfer facility would require about 8 million gal/yr of water (15 gpm). Following usual practice at the Portsmouth site, this water would be withdrawn from wells, and there would be no impact to surface water. During construction, about 4 million gal/yr (8 gpm) of wastewater would be discharged to the river. Because of dilution (260,000:1), contaminant concentrations would be reduced to considerably below regulatory standards.

K-25 Site. Construction of a cylinder transfer facility with a capacity of 320 cylinders per year at the K-25 site would increase runoff because about 8 acres (4 ha) of land would be replaced with paved lots and buildings (Table E.12). This increase in impermeable surface would produce a negligible impact on runoff because of the size of the existing watershed (0.5% of the land available).

Construction of the cylinder transfer facility would require about 6.5 million gal/yr (12 gpm) of water. This withdrawal would correspond to about 0.00059% of average river flow and would produce a negligible impact on water levels and floodplains. During construction, about 3.3 million gal/yr (6 gpm) of wastewater would be discharged to the river. Because of dilution (340,000:1), contaminant concentrations would be reduced to considerably below regulatory standards.

E.3.4.1.2 Operations

Paducah Site. For normal operations of the 1,600/yr cylinder transfer facility at the Paducah site, approximately 9 million gal/yr (17.1 gpm) of water would be withdrawn from surface water (Table E.12). This withdrawal would represent less than 0.000014% of the average river flow and would produce a negligible impact on water levels and floodplains.

About 7.1 million gal/yr (14 gpm) of wastewater would be discharged to the river during normal operations. This water would consist of sanitary wastewater, blowdown water from the cooling tower, industrial wastewater, and process water (LLNL 1997). This discharge would represent about 0.000012% of the average river flow and would produce a negligible impact on water levels and floodplains.

In addition to producing physical impacts to surface water, normal operations would also impact surface water quality. Approximately 0.00078 Ci/yr (about 112 µg/L) of uranium would be released to the river at the point of discharge (LLNL 1997). Although the concentration at the outfall would exceed the proposed U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 20 µg/L (EPA 1996) used as a guideline, the resulting uranium concentration (as well as the concentrations of other chemicals) in the river would be less than 20 µg/L because of dilution (9 million:1).

Portsmouth Site. For normal operations of the 960/yr cylinder transfer facility at the Portsmouth site, about 7 million gal/yr (13 gpm) of water would be required (Table E.12). Because this water would be withdrawn from wells, there would be no surface water impacts.

About 5.7 million gal/yr (11 gpm) of wastewater would be discharged to the river. This water would consist of sanitary wastewater, blowdown water, industrial wastewater, and process water (LLNL 1997). This discharge would represent about 0.00052% of the average river flow and would produce a negligible impact on water levels and floodplains.

Normal operations would also impact surface water quality. Approximately 0.00063 Ci/yr of uranium would be released to surface water (about 112 µg/L at the point of discharge). Although the concentration of uranium at the outfall would exceed the 20 µg/L guideline (EPA 1996), the resulting uranium concentration (as well as other chemicals) in the river would be less 20 µg/L because of dilution (200,000:1).

K-25 Site. For normal operation of the 320/yr cylinder transfer facility at the K-25 site, about 6 million gal/yr (11 gpm) of water would be required (Table E.12). This rate of withdrawal would represent about 0.00054% of the average river flow and would produce a negligible impact on water levels and floodplains.

About 4.4 million gal/yr (8 gpm) of wastewater would be discharged to the river. This water would consist of sanitary wastewater, blowdown water, industrial wastewater, and process water (LLNL 1997). This discharge would represent about 0.00038% of the average river flow and would produce a negligible impact on water levels and floodplains.

Normal operations would also impact surface water quality. Approximately 0.00049 Ci/yr of uranium would be released to surface water (about 112 µg/L at the point of discharge). Although the concentration of uranium at the outfall would exceed the 20 µg/L guideline (EPA 1996), the resulting uranium concentration (as well as other chemicals) in the river would be less than 20 µg/L because of dilution (255,000:1).

E.3.4.1.3 Accident Scenarios

No accidents are identified in LLNL (1997) that would directly affect surface water at any of the three storage sites. Secondary impacts resulting from deposition of airborne contaminants would not be measurable because of low concentrations in the deposited material.

E.3.4.2 Groundwater

For the cylinder overcontainer option and during preparation of standard cylinders, there would be no impacts to groundwater for any of the sites because there would be no discharges to the surface (LLNL 1997). For the cylinder transfer facility, impacts could occur during construction and normal operations; however, there would be no impacts from potential accidents because no accidents were identified in the engineering analysis report (LLNL 1997) that would release contaminants to the ground. Secondary impacts from air deposition would not be measurable because of the small concentrations of deposited material.

E.3.4.2.1 Construction

Paducah Site. Construction of the cylinder transfer facility at the Paducah site would result in decreased permeability of about 15 acres (6.1 ha) of land (Table E.12). This loss of permeable land would reduce recharge, increase depth to the water table, and change the direction of groundwater flow; however, because the affected area would be small (about 0.4% of the land available), the impacts would be local and negligible.

During construction, groundwater quality would also be impacted. For example, stockpiled chemicals could be mobilized by precipitation and infiltrate the surficial aquifer. By following good engineering and construction practices (e.g., covering chemicals to prevent interaction with rain, promptly cleaning up any spills, and providing retention basins to catch and hold contaminated runoff), groundwater concentrations would be less than the EPA guidelines.

Portsmouth Site. Construction of the cylinder transfer facility at the Portsmouth site would decrease the permeability of about 10 acres (4.1 ha) (Table E.12). This loss of permeable land would reduce recharge, increase depth to the water table, and change the direction of groundwater flow; however, because the affected area would be small (about 0.3% of the land available), the impacts would be local and negligible.

Construction of the cylinder transfer facility would require extracting 4 million gal/yr (8 gpm) from wells. This extraction would increase the daily withdrawal by less than 0.1% and would produce a negligible impact on depth to groundwater and direction of groundwater flow. Construction could also impact groundwater quality. By following good engineering and construction practices, groundwater concentrations would be less than the EPA guidelines.

K-25 Site. Construction of the cylinder transfer facility would decrease the permeability of about 8 acres (3.2 ha) (Table E.12). This loss of permeable land would reduce recharge, increase depth to the water table, and change the direction of groundwater flow; however, because the affected area would be small (about 0.5% of the land available), the impacts would be local and negligible. During construction, groundwater quality would also be impacted. By following good engineering and construction practices, groundwater concentrations would be less than the EPA guidelines.

E.3.4.2.2 Operations

Paducah Site. No impacts to groundwater would occur during normal operations at the Paducah site because no groundwater would be used and there would be no discharges to the ground.

Portsmouth Site. Normal operation of the cylinder transfer facility at the Portsmouth site would required an additional 7 million gal/yr of withdrawal from wells (Table E.12). This rate of withdrawal would represent an increase in daily extraction of about 0.1%. Because the rate of increased use would be small, impacts to the depth to the groundwater and its flow direction would be negligible. No impacts would occur to groundwater quality because there would be no direct discharges to the ground.

K-25 Site. No impacts to groundwater would occur during normal operations at the K-25 site because no groundwater would be used and there would be no discharges to the ground.

E.3.4.3 Soil

For the cylinder overcontainer option and during preparation of standard cylinders, there would be no impacts to soils from any of the three cases because there would be no discharges to the ground. For the cylinder transfer facility, the only impacts to the three sites would occur during construction; for normal operations, there would be no discharges to the ground, and there are no accidents identified in the engineering analysis report (LLNL 1997) that would lead to direct contamination of the soil. Secondary impacts to the soil from air deposition would be negligible because of the small concentrations of contaminants in the deposited material. Impacts from construction of the cylinder transfer facility include changes in topography, permeability, quality, and erosion potential.

E.3.4.3.1 Paducah Site

At the Paducah site, construction of a cylinder transfer facility with a capacity of 1,600 cylinders per year would disturb 21 acres (8.5 ha) of land (Table E.12). In the area of the construction, topography would be altered, permeability would be decreased in paved areas or areas that were compacted, permeability would increase in aerated areas, and erosion potential would decrease in compacted areas and increase in areas that were aerated. In general, these impacts would be negligible because the affected area would be small (about 0.6% of the land available), and in many cases, the impacts would be temporary (with regrading and reseeding, the soil would return to its former condition).

In addition to these physical changes, construction could also have a chemical impact on soil. By following good engineering and construction practices (e.g., covering chemicals with tarps, cleaning up spills as soon as they occur, and providing retention basins to catch and hold surface runoff), impacts to soil quality would be negligible.

E.3.4.3.2 Portsmouth Site

At the Portsmouth site, construction of a cylinder transfer facility with a capacity for 960 cylinders per year would disturb 14.3 acres (5.8 ha) of land (Table E.12). In the area of the construction, topography would be altered, permeability would be decreased in paved areas or areas that were compacted, permeability would increase in aerated areas, and erosion potential would decrease in compacted areas and increase in areas that were aerated. In general, these impacts would be negligible because the affected area would be small (about 0.4% of the land available), and in many cases, the impacts would be temporary (with regrading and reseeding, the soil would return to its former condition).

In addition to these physical changes, construction could also have a chemical impact on soil. By following good engineering and construction practices, impacts to soil quality would be negligible.

E.3.4.3.3 K-25 Site

At the K-25 site, construction of a cylinder transfer facility with a capacity for 320 cylinders per year would disturb 12 acres (4.9 ha) of land (Table E.12). In the area of the construction, topography would be altered, permeability would be decreased in paved areas or areas that were compacted, permeability would increase in aerated areas, and erosion potential would decrease in compacted areas and increase in areas that were aerated. In general, these impacts would be negligible because the affected area would be small (about 0.7% of the land available), and in many cases, the impacts would be temporary (with regrading and reseeding, the soil would return to its former condition).

In addition to these changes, construction could also have a chemical impact on soil. By following good engineering and construction practices, impacts to soil quality would be negligible.

E.3.5 Socioeconomics

The impacts of cylinder preparation on socioeconomic activity were estimated for a region of influence (ROI) at the three storage sites. Additional details regarding the assessment methodology is presented in Appendix C and Allison and Folga (1997).

Cylinder preparation would likely have a small impact on socioeconomic conditions in the ROIs surrounding the three sites described in Chapter 3, Sections 3.1.8, 3.2.8, and 3.3.8. This is partly because a major proportion of expenditures associated with procurement for the preoperation and operation of each preparation option would flow outside the ROI to other locations in the United States, reducing the concentration of local economic effects of each facility.

Slight changes in employment and income would occur in each ROI as a result of local spending of personal consumption expenditures derived from employee wages and salaries, local procurement of goods and services required for cylinder preparation activities, and other local investment associated with preoperations and operations. In addition to creating new (direct) jobs at each site, cylinder preparation would also create indirect employment and income in the ROI as a result of jobs and procurement expenditures at each site. Jobs and income created directly by cylinder preparation, together with indirect activity in the ROI, would contribute slightly to a reduction in unemployment in the ROI surrounding each site. Minimal impacts would be expected on local population growth and, consequently, on local housing markets and local fiscal conditions.

The effects of preoperating and operating cylinder preparation on regional economic activity, measured in terms of employment and personal income, and on population, housing, and local public revenues and expenditures are discussed in Sections E.3.5.1 through E.3.5.3. Impacts are presented for cylinder preparation at each of the storage sites for the peak year of preoperations and the first year of operations. The impacts of cylinder preparation at the three storage sites are given in Table E.13.

E.3.5.1 Paducah Site

E.3.5.1.1 Impacts from Cylinder Preparation Using Overcontainers

During the peak year of preoperations for cylinder preparation using overcontainers, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with \$0.2 million of total income produced during the peak year. During the first year of operations involving overcontainers, 230 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with \$9 million in total income produced. Activities associated with overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.02 percentage points from 1999 through 2028.

Preoperations involving overcontainers would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational

TABLE E.13 Potential Socioeconomic Impacts of the Cylinder Preparation Options at the Three Sites

	Cylinder Overcontainers		Cylinder Transfer Facility		Standard Cylinder Preparation	
Site/Parameter	Preoperation[a]	Operations[b]	Construction[a]	Operations[b]	Preoperation[a]	Operations[b]
Paducah Site						
Economic activity in the ROI						
Direct jobs	<5	120	260	200	<5	60
Indirect jobs	<5	110	130	170	<5	60
Total jobs	<5	230	390	370	<5	120
Direct income ($ million)	0.1	8	12	10	0.1	4
Total income ($ million)	0.2	9	14	13	0.1	5
Population in-migration into the ROI	<5	230	440	390	<5	100
Housing demand						
Number of units in the ROI	<5	80	160	140	<5	40
Public finances						
Change in ROI fiscal balance (%)	0	0.1	0.3	0.3	0	0.1
Portsmouth Site						
Economic activity in the ROI						
Direct jobs	<5	100	190	160	<5	50
Indirect jobs	<5	80	90	180	<5	40
Total jobs	<5	180	280	350	<5	90
Direct income ($ million)	0.1	6	8	8	0.1	3
Total income ($ million)	0.2	7	10	11	0.1	4
Population in-migration into the ROI	<5	200	320	330	<5	100
Housing demand						
Number of units in the ROI	<5	80	120	120	<5	40
Public finances						
Change in ROI fiscal balance (%)	0	0.1	0.2	0.2	0	0.1

TABLE E.13 (Cont.)

Site/Parameter	Cylinder Overcontainers: Preoperation[a]	Cylinder Overcontainers: Operations[b]	Cylinder Transfer Facility: Construction[a]	Cylinder Transfer Facility: Operations[b]	Standard Cylinder Preparation: Preoperation[a]	Standard Cylinder Preparation: Operations[b]
K-25 Site						
Economic activity in the ROI						
Direct jobs	<5	80	130	130	<5	40
Indirect jobs	<5	120	160	380	<5	60
Total jobs	<5	200	290	510	<5	100
Direct income ($ million)	0.1	5	6	7	0.1	2
Total income ($ million)	0.2	6	9	13	0.1	3
Population in-migration into the ROI	<5	190	220	240	<5	80
Housing demand						
Number of units in the ROI	<5	70	80	90	<5	30
Public finances						
Change in ROI fiscal balance (%)	0	0.1	0.04	0.04	0	0.01

[a] Impacts are for peak year of preoperation or construction, 2007. The preoperational (construction) phase was assessed from 1999 through 2008.

[b] Impacts are the annual averages for operations for the period 2009 through 2028.

activities for cylinder overcontainers would be expected to generate direct and indirect job in-migration of 230 in the first year of operations. Preoperational and operational activities for overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

Cylinder overcontainer activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing an impact of 0.1% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 80 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 1.8% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 230 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.1.2 Impacts from a Cylinder Transfer Facility

During the peak year of construction of a cylinder transfer facility, 260 direct jobs would be created at the site and 130 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 390 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $14 million of total income produced during the peak year. During the first year of operations of the cylinder transfer facility, 370 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $13 million in total income produced. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.04 percentage points from 1999 through 2028.

Construction of the cylinder transfer facility would be expected to generate direct in-migration of 360 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 440 in the peak year. Operation of the cylinder transfer facility would be expected to generate direct and indirect job in-migration of 390 in the first year of operations. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.02 percentage points from 1999 through 2028.

The cylinder transfer facility would generate a demand for 160 additional rental housing units during the peak year of construction, representing an impact of 10.4% on the projected number of vacant rental housing units in the ROI (Table E.13). The demand for 140 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 3.0% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 440 people would be expected to in-migrate into the ROI, leading to an increase of 0.3% over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 390 in-migrants would be expected, leading to an increase of 0.3% in local revenues and expenditures.

E.3.5.1.3 Impacts from Standard Cylinder Preparation

During the peak year of preoperational activities for standard cylinder preparation, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.1 million of total income produced during the peak year. During the first year of operations for standard cylinder preparation, 120 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $5 million in total income produced. Preoperational and operational activities for standard cylinder preparation would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Preoperational activities for standard cylinder preparation would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for standard cylinder preparation would be expected to generate direct and indirect job in-migration of 100 in the first year of operations. Preoperational and operational activities would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

Standard cylinder preparation activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing an impact of 0.0% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 40 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.8% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 100 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.2 Portsmouth Site

E.3.5.2.1 Impacts from Cylinder Preparation Using Overcontainers

During the peak year of preoperation for standard cylinder preparation using overcontainers, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperation activities would also produce direct and indirect income in the ROI surrounding the site, with $0.2 million of total income produced during the peak year. During the first year of operations involving overcontainers, 180 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $7 million in total income produced. Activities associated with overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.02 percentage points from 1999 through 2028.

Preoperations involving overcontainers would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for cylinder overcontainers would be expected to generate direct and indirect job in-migration of 200 in the first year of operations. Preoperational and operational activities for overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

Cylinder overcontainer activities would generate a demand for fewer than 5 additional rental housing unit during the peak year of preoperations, representing an impact of 0.1% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 80 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 1.6% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 200 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.2.2 Impacts from a Cylinder Transfer Facility

During the peak year of construction of a cylinder transfer facility, 190 direct jobs would be created at the site and 90 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 280 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $10 million of total income produced during the peak year. During the first year of operations of the cylinder transfer facility, 350 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $11 million in total income produced. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.03 percentage points from 1999 through 2028.

Construction of the cylinder transfer facility would be expected to generate direct in-migration of 260 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 320 in the peak year. Operation of the cylinder transfer facility would be expected to generate direct and indirect job in-migration of 330 in the first year of operations. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.01 percentage points from 1999 through 2028.

The cylinder transfer facility would generate a demand for 120 additional rental housing units during the peak year of construction, representing an impact of 5.9% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 120 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.2% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 320 people would be expected to in-migrate into the ROI, leading to an increase of 0.2% over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 330 in-migrants would be expected, leading to an increase of 0.2% in local revenues and expenditures.

E.3.5.2.3 Impacts from Standard Cylinder Preparation

During the peak year of preoperational activities for standard cylinder preparation, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.1 million of total income produced during the peak year. During the first year of operations for standard cylinder preparation, 90 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $4 million in total income produced. Preoperational and operational activities for standard cylinder preparation would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Preoperational activities for standard cylinder preparation would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for standard cylinder preparation would be expected to generate direct and indirect job in-migration of 100 in the first year of operations. Preoperational and operational activities would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.004 percentage points from 1999 through 2028.

Standard cylinder preparation activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing essentially no impact on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 40 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.7% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 100 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.3 K-25 Site

E.3.5.3.1 Impacts from Cylinder Preparation Using Overcontainers

During the peak year of preoperations for cylinder preparation using overcontainers, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.2 million of total income produced during the peak year. During the first year of operations involving overcontainers, 200 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $6 million in total income produced. Activities associated with overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Preoperations involving overcontainers would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for cylinder overcontainers would be expected to generate direct and indirect job in-migration of 190 in the first year of operations. Preoperational and operational activities for overcontainers would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.03 percentage points from 1999 through 2028.

Cylinder overcontainer activities would generate a demand for fewer than 5 additional rental housing units during the peak year of preoperations, representing an impact of 0.1% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 70 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.6% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 190 in-migrants would be expected, leading to an increase of 0.1% in local revenues and expenditures.

E.3.5.3.2 Impacts from a Cylinder Transfer Facility

During the peak year of construction of a cylinder transfer facility, 130 direct jobs would be created at the site and 160 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, 290 jobs would be created. Construction activity would also produce direct and indirect income in the ROI surrounding the site, with $9 million of total income produced during the peak year. During the first year of operations of the cylinder transfer facility, 510 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $13 million in total income produced. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Construction of the cylinder transfer facility would be expected to generate direct in-migration of 170 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to 220 in the peak year. Operation of the cylinder transfer facility would be expected to generate direct and indirect job in-migration of 240 in the first year of operations. Construction and operation of the transfer facility would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.004 percentage points from 1999 through 2028.

The cylinder transfer facility would generate a demand for 80 additional rental housing units during the peak year of construction, representing an impact of 1.5% on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 90 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.8% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of construction, 220 people would be expected to in-migrate into the ROI, leading to an increase of 0.04% over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 240 in-migrants would be expected, leading to an increase of 0.04% in local revenues and expenditures.

E.3.5.3.3 Impacts from Standard Cylinder Preparation

During the peak year of preoperational activities for standard cylinder preparation, fewer than 5 direct jobs would be created at the site and fewer than 5 additional jobs indirectly in the ROI (Table E.13) as a result of the spending of employee wages and salaries and procurement-related expenditures. Overall, fewer than 5 jobs would be created. Preoperational activities would also produce direct and indirect income in the ROI surrounding the site, with $0.1 million of total income produced during the peak year. During the first year of operations for standard cylinder preparation, 100 direct and indirect jobs would be created. Direct and indirect income would also be produced in the ROI, with $3 million in total income produced. Preoperational and operational activities for standard cylinder preparation would result in an increase in the projected baseline compound annual average growth rate in ROI employment of 0.01 percentage points from 1999 through 2028.

Preoperational activities for standard cylinder preparation would be expected to generate direct in-migration of fewer than 5 in the peak year (Table E.13). Additional indirect job in-migration would also be expected, bringing the total number of in-migrants to fewer than 5 in the peak year. Operational activities for cylinder preparation would be expected to generate direct and indirect job in-migration of 80 in the first year of operations. Preoperational and operational activities would result in an increase in the projected baseline compound annual average growth rate in ROI population of 0.001 percentage points from 1999 through 2028.

Standard cylinder preparation activities would generate a demand for fewer than 5 additional rental housing unit during the peak year of preoperations, representing essentially no impact on the projected number of vacant rental housing units in the ROI (Table E.13). A demand for 30 additional owner-occupied housing units would be expected in the first year of operations, representing an impact of 0.3% on the number of vacant owner-occupied housing units in the ROI.

During the peak year of preoperations, fewer than 5 people would be expected to in-migrate into the ROI, leading to essentially no increase over ROI-forecasted baseline revenues and expenditures (Table E.13). In the first year of operations, 80 in-migrants would be expected, leading to an increase of 0.01% in local revenues and expenditures.

E.3.6 Ecology

Predicted concentrations of contaminants in environmental media were compared with benchmark values of toxic and radiological effects to assess impacts to terrestrial and aquatic biota. Discussion of assessment methodology is presented in Appendix C.

No ecological impacts would be expected during preparation of standard cylinders. Under the cylinder overcontainer option, no site preparation or construction would occur. Normal operations would not result in impacts to surface water, groundwater, or soil (Section E.3.4). Atmospheric releases of contaminants would include only criteria pollutants, and emission levels would be expected to be extremely low (Section E.3.3). Therefore, impacts of the cylinder overcontainer option to ecological resources would be negligible.

Impacts to ecological resources could result from construction of a cylinder transfer facility. Impacts could include mortality of individual organisms, habitat loss, or changes in biotic communities. Impacts due to operation of a cylinder transfer facility could result from exposure to airborne contaminants or contaminants released to soils, groundwater, or surface waters or changes in surface water or groundwater quality or flow rates.

E.3.6.1 Paducah Site

Site preparation for the construction of a cylinder transfer facility at the Paducah site would require the disturbance of approximately 21 acres (9 ha), including the permanent replacement of approximately 15 acres (6 ha), primarily with structures and paved areas. Existing vegetation would be destroyed during land clearing activities. Determination of the vegetation communities that would be eliminated by site preparation would depend on the exact location of the facility. Communities occurring on undeveloped land at the site are relatively common and well represented in the vicinity of the site; however, impacts to high quality native plant communities might occur if facility construction required disturbance to vegetation communities outside of the currently fenced site area (see Section E.3.9 for a discussion of land use). Construction of the transfer facility would not be expected to threaten the local population of any species. The loss of up to 21 acres (9 ha) of undeveloped land would constitute a moderate adverse impact to vegetation. Erosion of exposed soil at the construction site could reduce the effectiveness of restoration efforts and create sedimentation downgradient of the site. The implementation of standard erosion control measures, installation of storm-water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Impacts due to facility construction are shown in Table E.14.

TABLE E.14 Potential Impacts to Ecological Resources from Construction of the Cylinder Transfer Facility at the Paducah Site

Resource	Type of Impact	Degree of Impact
Vegetation	Loss of 21 acres	Moderate adverse impact
Wildlife	Loss of 15 to 21 acres	Moderate adverse impact
Wetlands	Loss, degradation	Potential adverse impact
Aquatic species	Water quality, habitat reduction	Negligible impact
Protected species	Destruction, habitat loss	Potential adverse impact

Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land-clearing activities. More mobile individuals would relocate to adjacent available areas with suitable habitat. Population densities and competition would increase in these areas, potentially reducing the chances of survival or reproductive capacity of displaced individuals. Some wildlife species would be expected to quickly recolonize replanted areas near the facility following completion of construction. The permanent loss of 15 to 21 acres (6 to 9 ha) of habitat would not be expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the site. Construction of a cylinder transfer facility would be considered a moderate adverse impact to wildlife.

Impacts to surface water and groundwater quality during construction are expected to be negligible (Section E.3.4). Thus, construction-derived impacts to aquatic biota would also be expected to be negligible. Wetlands could potentially be impacted by filling or draining during construction. In addition, impacts to wetlands due to alteration of surface water runoff patterns, soil compaction, or groundwater flow could occur if the facility were located immediately adjacent to wetland areas. However, impacts to wetlands would be minimized by maintaining a buffer area around wetlands during construction of the facility. Unavoidable impacts to wetlands would require a *Clean Air Act* Section 404 permit, which might stipulate mitigative measures. Additional permitting might be required by state agencies.

Critical habitat has not been designated for any federal- or state-listed threatened or endangered species at the Paducah site. Prior to construction of the transfer facility, a survey would be conducted for federal- and state-listed threatened, endangered, or candidate species, or species of special concern. Impacts to these species could thus be avoided or, when impacts were unavoidable, appropriate mitigation could be developed.

Water withdrawal from surface waters or groundwater, as well as wastewater discharge, during facility construction and operation could potentially alter water levels. The changes in water levels could in turn affect aquatic ecosystems, including wetlands, such as those located along the periphery of these surface water bodies. However, water-level changes due to water withdrawal and wastewater discharge would be negligible (Section E.3.4). Therefore, impacts to wetlands and aquatic communities would be expected to be negligible.

Ecological resources in the vicinity of the transfer facility would be exposed to atmospheric emissions from the boiler stack and process stack; however, emission levels would be expected to be extremely low (Section E.3.3.1), well below concentrations known to adversely affect biota. Resulting impacts to biota would be expected to be negligible. Impacts due to facility operation are shown in Table E.15.

TABLE E.15 Potential Impacts to Ecological Resources from Operation of the Cylinder Transfer Facility at the Paducah Site

Contaminant	Biota	Maximum Exposure	Impact
HF	Wildlife	3.1×10^{-5} µg/m^3	Negligible
UO_2F_2 in air	Wildlife	2.1×10^{-6} µg/m^3	Negligible
Uranium in surface water	Aquatic	112 µg/L	Negligible

Effluent discharges to surface waters could contain a number of chemical contaminants. Facility wastewater would have a uranium concentration of about 112 µg/L in the undiluted effluent (Section E.3.4.1). Dilution of the discharge in the receiving stream by a factor in excess of 150,000 would result in negligible concentrations (Section E.3.4.1). Thus, impacts to aquatic biota in the vicinity of the outfall would be negligible.

Facility accidents, as discussed in Section E.3.2, could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors such as location of the accident, season, and meteorological conditions.

E.3.6.2 Portsmouth Site

Construction of a cylinder transfer facility at the Portsmouth site would result in the types of impacts associated with the Paducah facility. However, a smaller area would be required. Facility construction would disturb approximately 14 acres (6 ha), including the permanent replacement of 10 acres (4 ha), primarily with structures and paved areas. Construction of the transfer facility would not be expected to threaten the local population of any species. In addition to site-specific surveys for protected species, avoidance of wooded areas would reduce the potential for impacts to the sharp-shinned hawk (state-listed as endangered) and Indiana bat (federal- and state-listed as endangered). The loss of up to 14 acres (6 ha) of undeveloped land and 10 to 14 acres (4 to 6 ha) of habitat would constitute a moderate adverse impact to vegetation and wildlife.

Operation of a cylinder transfer facility at the Portsmouth site would result in lower atmospheric emissions of contaminants than predicted for the Paducah facility. Resulting impacts to biota would, therefore, also be negligible. Uranium concentrations in discharges to surface water would be slightly lower than predicted for the Paducah facility. Resulting impacts to aquatic biota would also be negligible.

E.3.6.3 K-25 Site

Construction of a cylinder transfer facility at the K-25 site would result in the types of impacts associated with the Paducah and Portsmouth facilities. However, a smaller area would be required. Facility construction would disturb approximately 12 acres (5 ha), including the permanent replacement of 8 acres (3 ha), primarily with structures and paved areas. Construction of the transfer facility would not be expected to threaten the local population of any species. The loss of up to 12 acres (5 ha) of undeveloped land and 9 to 12 acres (4 to 5 ha) of habitat would constitute a moderate adverse impact to vegetation and wildlife.

Operation of a cylinder transfer facility at the K-25 site would result in lower atmospheric emissions of contaminants than predicted for the Paducah or Portsmouth facilities. Resulting impacts to biota would, therefore, also be negligible. Uranium concentrations in discharges to surface water would be slightly lower than predicted for the Paducah or Portsmouth facilities. Resulting impacts to aquatic biota would also be negligible.

E.3.7 Waste Management

Estimates of waste generation were based on the total number of cylinders at each site. No liquid wastes would be expected at the sites as a result of cylinder shipment activities from either standard cylinders or cylinders in overcontainers. The only solid waste generated in these activities would be personal protective equipment and wipes and rags that would be used to remove surface contamination on the cylinders. These wastes are categorized as combustible solid low-level radioactive waste (LLW) and are shown in Table E.16 for each of the three sites. It was assumed that the LLW would be generated during removal of surface contamination and would be independent of the cylinders being standard or substandard. Thus, the amount of waste in this operation would be proportional to the total number of cylinders at the site. It was assumed that no cylinder breaches would occur inside the overcontainers during transportation.

The waste input resulting from the cylinder overcontainer operations would have minimal impact on radioactive waste management capabilities at any of the three sites or on a national level. The impact on site nonradiological waste management would also be negligible.

The estimated total quantities of solid and liquid wastes generated from activities associated with the construction of the cylinder transfer facility are shown in Table E.17. The type and quantity of solid and liquid waste expected to be generated from the operation of the cylinder transfer facility are shown in Table E.18, based on a throughput cylinder capacity of 5% of the total cylinder inventory at each site. The different types of waste generated during the operation of this facility would include LLW, low-level mixed waste (LLMW), hazardous waste, and nonhazardous waste.

TABLE E.16 Waste Generated with Activities for Cylinder Overcontainers or Standard Cylinder Preparation[a]

Site	Waste Generated		
	Waste Type[b]	Annual Volume (m^3/yr)	Uranium Form
Paducah	LLW (combustible solids)	12.7	UO_2F_2
Portsmouth	LLW (combustible solids)	7.0	UO_2F_2
K-25	LLW (combustible solids)	2.8	UO_2F_2

[a] Decontamination of the overcontainer surfaces was assumed to be performed at the conversion/storage facility prior to the overcontainer being sent back to the site for reuse.

[b] It was assumed that the low-level waste would be generated during removal of surface contamination and would be independent of the cylinder being standard or substandard.

TABLE E.17 Total Wastes Generated during Construction of the Cylinder Transfer Facility: Base Case

Waste Category	Quantity
Hazardous solids	38 m^3
Hazardous liquids	20,000 gal
Nonhazardous solids	
Concrete	76 m^3
Steel	30 tons
Other	612 m^3
Nonhazardous liquids	
Sanitary	3 million gal
Other	1 million gal

TABLE E.18 Estimated Annual Radioactive, Hazardous, and Nonhazardous Wastes Generated during Operation of the Cylinder Transfer Facility at the Three Sites

		Annual Volume (m^3)			
Type of Waste	Description of Waste	Paducah	Portsmouth	K-25	Contaminants
Low-Level Waste					
Combustible solids	Gloves, wipes, clothing, etc.	91	43	15	17 lb UO_2F_2
Metal, surface-contaminated	Failed equipment	12	5.3	2.2	16 lb UO_2F_2
Noncombustible compactible solids	HEPA filters	46	11	8.0	54 lb UO_2F_2
	Grouted waste	2.8	1.3	0.44	135 lb $UO_2(OH)_2$
Other	Lab packs (chemicals)	0.5	0.27	0.11	0.75 lb UO_2F_2
Low-Level Mixed Waste					
Lab packs	Chemicals	0.3	0.13	0.04	0.37 lb UO_2F_2
Inorganic process debris	Failed equipment	0.3	0.13	0.04	0.37 lb UO_2F_2
Combustible debris	Wipes, etc.	0.3	0.13	0.04	0.07 lb UO_2F_2
Hazardous Waste					
Organic liquids	Solvents, oil, paint, thinner	0.8	0.35	0.18	
Inorganic process debris	Failed equipment	1.2	0.6	0.26	1.5 lb HF, 2 lb NaOH
Combustible debris	Wipes, etc.	1.2	0.6	0.26	0.75 lb HF, 1 lb NaOH
Nonhazardous Waste					
Nonhazardous solid waste	Nonhazardous solid waste	87	46	20	
Nonhazardous liquid waste	Cooling tower blowdown process water, etc.	460	220	76	
Recyclable waste	Recyclable waste	180	85	30	

Notation: HEPA = high-efficiency particulate air (filters); HF = hydrogen fluoride; NaOH = sodium hydroxide; UO_2F_2 = uranyl fluoride; $UO_2(OH)_2$ = uranyl hydroxide.

The primary waste produced in the transfer process would be empty UF_6 cylinders and grouted waste drums. Radioactive or hazardous liquid materials would include decontamination liquids, laboratory liquid wastes, contaminated cleaning solution, lubricants, and paints. Radioactive or hazardous solid wastes would include failed process equipment, HEPA filters, laboratory wastes, wipes, rags, and operator-contaminated clothing. The LLW would be shipped off-site for disposal, and the LLMW and hazardous waste would be shipped off-site for both treatment and disposal. The total volume of crushed, empty UF_6 cylinders would be about 125,000 m^3. For the PEIS analysis, it was assumed that the treated cylinders would become part of the DOE scrap metal inventory. If a disposal decision were made, the treated cylinders could be disposed of as LLW, representing a 3% addition to the total projected DOE complex-wide LLW disposal volume.

Overall, the waste input resulting from construction and operation of a transfer facility would add about 7% to the Paducah site LLW generation and less at the Portsmouth and K-25 sites (see Appendix C, Table C.3), based on the different-sized treatment facilities at each site. The input of LLMW and nonhazardous wastes from the transfer facility would represent less than 1% of each site's LLMW or nonhazardous waste loads.

The waste input resulting from the construction and operation of the transfer facility would have minimal impact on radioactive waste management capabilities at any of the three sites. The impact on nonradiological site waste management would also be negligible. The impacts of waste resulting from the operation of the depleted UF_6 transfer facility on national waste management capabilities would be negligible.

E.3.8 Resource Requirements

Cylinder overcontainers would be constructed primarily from steel purchased from existing steel vendors. The preliminary overcontainer design requires approximately 8,000 lb (3,600 kg) of steel per overcontainer (LLNL 1997). Resources would be required only for the construction of overcontainers. No substantial resources would be required for the use of the overcontainers. Because the overcontainers would be reusable, it is estimated that the total number of overcontainers required would be approximately 581 (LLNL 1997). This total assumes a 10% contingency for spares, unforeseen delays, and the few overcontainers that might be needed at the cylinder treatment facility. The total amount of steel required for the overcontainers would be about 4,640,000 lb (2,110,000 kg). Based upon the total steel required for construction of overcontainers, no impact on local or national steel availability or production would be expected (Standard & Poor's 1996; U.S. Bureau of the Census 1996). No other materials of significant quantity would be required.

Resource needs for the cylinder transfer facility are presented in Table E.19 as utilities consumed during construction and operations at the three sites. The facility was assumed to operate 24 hours per day, 7 days per week, and 292 days per year for an 80% plant availability during operations.

The process equipment would be purchased from equipment vendors. The total quantities of commonly used construction material (i.e., steel) for equipment would be minor as compared to the quantities for construction. The primary specialty material used for equipment fabrication is at most approximately 7 tons of Monel. The material quantities required for construction and operation of the cylinder transfer facility would be minor compared to local and national supplies.

E.3.9 Land Use

No impacts to land use from cylinder overcontainer operations at any of the current cylinder storage sites would be expected. No additional land would be required, and no new construction

TABLE E.19 Resource Requirements for Construction and Operation of the Cylinder Transfer Facility

		Total Requirement		
Material/Resource	Unit	Paducah	Portsmouth	K-25
Construction				
Utilities				
Electricity	GWh	40	35	25
Solids				
Concrete	yd^3	23,000	20,000	16,000
Steel	tons	9,000	8,000	6,000
Liquids				
Fuel	million gal	1.8	1.5	1.2
Gases				
Industrial gases	gal	5,000	4,400	3,500
Specialty material (Monel)	tons	7	5	4
Operations				
Utilities				
Electricity	GWh/yr	14.6	10.8	7.1
Solids				
Cement	lb	2,700	1,600	530
Potassium hydroxide	lb	4,600	2,700	930
Liquids				
Sulfuric acid	lb/yr	2,400	1,400	470
Hydrochloric acid	lb/yr	1,900	1,300	970
Sodium hydroxide	lb/yr	1,500	1,100	770
Liquid fuel	gal/yr	6,000	5,500	4,800
Gases				
Natural gas	million scf/yr	48.5	35	26

would be necessary. Existing handling and support equipment would be utilized with no modifications required (LLNL 1997). No off-site traffic impacts would be encountered during operations because the required labor force would not appreciably affect local traffic patterns or flows.

Impacts to land use from the construction and operation of a cylinder transfer facility would be negligible and limited to temporary disruptions to contiguous land parcels and potential minor traffic disruptions from peak year construction activities. Areal requirements would be small (approximately 21 acres or less), regardless of whether or not the facility were located at one or all of the current cylinder storage sites.

The peak construction labor force for the cylinder transfer facility could result in potential off-site traffic impacts in the vicinity of the three sites, although such impacts would be negligible and would ease as construction neared completion.

E.3.10 Cultural Resources

No impacts to cultural resources would be expected at the Paducah, Portsmouth, and K-25 sites as a result of the cylinder overcontainer option for cylinder preparation. Impacts could result from the cylinder transfer option during construction of the transfer facility at one of the sites. Specific impacts cannot be determined at this time and would depend on the exact location of a facility within each site and whether eligible cultural resources existed on or near that location. Operation of the transfer facility would not affect cultural resources.

E.3.11 Environmental Justice

The analysis of human health and environmental impacts associated with the cylinder overcontainer operations (Sections E.3.1 through E.3.9) indicates that no high and adverse human health effects would be expected at any of the current cylinder storage sites during normal operations. Consequently, no particular segment of the population, including minority and low-income persons, would be disproportionately affected. The results of accident analyses for cylinder preparation did not identify high and adverse impacts to the general public (i.e., the risk of accidents, consequence times probability, was less than 1).

The construction and operation of a cylinder transfer facility at any or all of the three storage sites would not result in disproportionate effects on minority or low-income populations. The analysis of human health effects and environmental impacts associated with a cylinder transfer facility (Sections E.3.1 through E.3.9) indicates that no high and adverse human health effects or environmental impacts would be expected.

E.3.12 Other Impacts Considered But Not Analyzed in Detail

Other impacts that could potentially occur if the cylinder preparation options considered in this PEIS were implemented include impacts to the visual environment (e.g., aesthetics), recreational resources, and noise levels, as well as impacts associated with decontamination and decommissioning of the cylinder transfer facilities. These impacts, although considered, were not analyzed in detail for one or more of the following reasons:

- Consideration of these impacts would not contribute to differentiation among the alternatives and, therefore, would not affect the decisions to be made in the Record of Decision to be issued following publication of this PEIS; or

- Impacts to the visual environment, recreational resources, and noise levels would be expected to stay the same as they are because cylinder preparation activities would be similar to the cylinder management activities currently ongoing at the three sites.

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