5 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

Potential impacts to workers, members of the general public, and the environment were estimated for each of the alternative management strategies considered in this PEIS. This chapter presents those impacts associated with the management of the depleted UF_6 cylinder inventory generated by DOE prior to the formation of USEC in July 1993. The potential impacts associated with the management of USEC-generated cylinders that became the responsibility of DOE in May and June of 1998 are presented in Chapter 6. The general assessment methodologies and major assumptions used to estimate the impacts presented in this chapter are described in Chapter 4, with additional detailed methodology information provided in Appendix C.

Each of the PEIS alternatives is composed of combinations of several activities (see Chapter 2 and Figure 2.1). These management activities are addressed in detail in Appendices D through K:

- Appendix D — Environmental Impacts of Continued Cylinder Storage at Current Storage Sites
- Appendix E — Environmental Impacts of Options for Preparing Cylinders for Shipment or Long-Term Storage
- Appendix F — Environmental Impacts of Options for Conversion of UF_6 to Oxide or Metal
- Appendix G — Environmental Impacts of Options for Long-Term Storage as UF_6 and Uranium Oxide
- Appendix H — Environmental Impacts of Options for the Manufacture and Use of Uranium Oxide and Uranium Metal
- Appendix I — Environmental Impacts of Options for Disposal of Oxide
- Appendix J — Environmental Impacts of Transportation of UF_6 Cylinders, Uranium Oxide, Uranium Metal, and Associated Materials
- Appendix K — Parametric Analysis: Environmental Impacts for Processing Less than the Total Depleted UF_6 Inventory

Each appendix provides a discussion of the types of activities that would occur, the representative technologies and facilities considered, and the estimated environmental impacts associated with each option.

The potential environmental impacts assessed for this PEIS were determined by combining the impacts associated with each of the individual activities necessary to implement each alternative (as shown in Figures 2.1 through 2.7). Where appropriate, the impacts are presented as ranges, which account for differences in both the possible options and technologies that could be used and the effects that different environmental settings might have on the estimated environmental impacts. The discussion in this chapter focuses on the most significant issues and potential environmental impacts. Additional discussion of the analyses supporting the impacts reported here is presented in Appendices D through K.

Because sites for new facilities will be selected in Phase II of the Depleted Uranium Hexafluoride Management Program, the potential impacts presented for alternatives other than the no action alternative include a mixture of site-specific impacts and impacts calculated for representative or generic environmental settings. The level of analysis conducted depended on the specific activity considered. Continued cylinder storage and cylinder preparation activities would take place at the three current cylinder storage sites (Paducah, Portsmouth, and K-25). Potential impacts of these activities were thus assessed on a site-specific basis. Potential impacts of conversion and long-term storage (in buildings, vaults, and yards) were assessed for representative settings, and potential impacts of manufacture and use, long-term storage in a mine, and disposal were evaluated for generic settings (see Chapters 3 and 4 for descriptions of the environmental settings). Subsequent analysis with more site-specific environmental considerations will be performed during the Phase II analyses and NEPA reviews, as appropriate.

To provide a conservative analysis of transportation and construction impacts, it was assumed that facilities for conversion, long-term storage, manufacture and use, and disposal would be located at separate sites other than the three current storage sites. This approach was intended to provide a conservative estimate of the total impacts associated with the alternatives because it would require the transportation of materials between sites and the construction of new facilities and supporting infrastructure. The transportation impacts were analyzed using representative route characteristics for a range of possible distances between sites. Colocating facilities is consistent with Public Law 105-204 and DOE's current plan. Colocation could reduce or even eliminate the transportation of uranium and associated materials and possibly reduce the amount of land and construction activities required. The impacts of colocating facilities are discussed in Section 5.8.3.

For all alternatives, potential environmental impacts were evaluated for the period 1999 through 2039. For the continued storage component of all alternatives and for the disposal alternative, potential long-term impacts were also evaluated, primarily with respect to groundwater contamination. Because depleted uranium would require management beyond 2039, a discussion of potential actions and impacts that might occur beyond that date (i.e., life-cycle impacts) is provided in Section 5.9. Detailed analysis was generally not conducted beyond 2039 because actions and impacts beyond that time are highly uncertain, and thus decisions related to them are not ready to be made at this time.

5.1 NO ACTION ALTERNATIVE

Under the no action alternative, depleted UF_6 cylinder storage would continue at each of the three current storage sites indefinitely. The potential environmental impacts were estimated through the year 2039. In addition, the long-term impacts from potential groundwater contamination were estimated. A detailed discussion of site-specific impacts of continued cylinder storage at each of the three current storage sites is presented in Appendix D. This section provides a summary of those impacts.

The potential environmental impacts of the no action alternative were based on the cylinder management activities that will take place at the sites in the future. Current detailed cylinder management plans extend through the year 2002 (LMES 1997i). The ongoing and planned activities are designed to ensure continued safe storage of cylinders. These activities include cylinder inspections, cylinder yard upgrades, cylinder painting, and cylinder maintenance and repair activities. Beyond 2002, a set of cylinder management assumptions was needed to define the activities that would probably occur at the sites through 2039 so that the potential impacts could be estimated. It was assumed that the types of activities that would occur generally would be similar to those that are now ongoing or planned (Parks 1997). The assumptions were chosen in such a way that the impacts would be overestimated rather than underestimated.

Specifically, the activities assumed to occur at the sites during the no action alternative include a comprehensive cylinder monitoring and maintenance program, with routine cylinder inspections, ultrasonic thickness testing of cylinders, radiological surveys, cylinder painting to prevent corrosion, cylinder yard surveillance and maintenance, construction of four new or improved storage yards at the Paducah site and one at K-25 site between 1999 and 2002, and relocation of some cylinders at all three sites. Cylinders were assumed to be painted every 10 years. These activities are described in greater detail in Appendix D.

An important issue with respect to potential environmental impacts of continued cylinder storage is the expected condition of the cylinders over time. During storage that has been ongoing from the mid-1950s to the present, previous substandard storage conditions have led to corrosion and pitting of many cylinder surfaces, and eight breached cylinders have been identified and repaired. These cylinders had holes in their walls in sizes ranging from very small (1/16 in. [0.16 cm]) to 15 in. (38 cm) in diameter. Corrosion of the cylinders in the past occurred while many of the cylinders were stored in substandard cylinder yard conditions. In addition, cylinders were not routinely painted to control corrosion. An intensive program has been ongoing for several years to improve the storage conditions of the cylinders. Some storage yards have been reconstructed, and new storage yards with concrete bases and controlled runoff have been added. Many cylinders have been relocated to better storage conditions. The improved storage yard conditions are expected to decrease corrosion rates.

In addition, the cylinder painting program is expected to control external corrosion of the cylinders (Pawel 1997).

For assessment of the no action alternative, it was assumed that the cylinder maintenance and painting program would protect the cylinders from further corrosion. The cylinders would continue to corrode at the historical rates until painted. Some future cylinder breaches were assumed to occur from handling damage after the initial painting. Although unlikely, for analysis purposes these breaches were assumed to go undetected for 4 years (the inspection interval for most cylinders) and to release some uranium and HF to the environment. The number of future cylinder breaches through 2039 was estimated to be 36 at the Paducah site, 16 at the Portsmouth site, and 7 at the K-25 site (see Appendix B).

Although it is expected that cylinder maintenance and painting will control cylinder corrosion, there are some uncertainties concerning the future condition of the cylinders. Current estimates suggest a paint effectiveness of at least 10 years (Pawel 1997). However, it is possible that the cylinders would not be painted every 10 years because of budget or other considerations. In addition, it is possible that the paint might not be effective for 10 years. Because of these uncertainties, an assessment was also conducted on the basis of the assumption that external corrosion would not be halted by improved storage conditions, cylinder maintenance, and painting. Assuming that corrosion rates would continue at the historical rate (poor storage conditions and no routine painting), many more breaches would be expected to occur over time at the three storage sites. The total number of breaches through 2039 was estimated to be about 440 at Paducah, 70 at Portsmouth, and 210 at K-25 (see Appendix B). The results of this assessment were used to provide an estimate of the earliest time when continued cylinder storage could begin to raise regulatory concerns if external corrosion of the cylinders was not controlled.

5.1.1 Human Health and Safety

Under the no action alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. In general, the impacts during normal facility operations at all sites would be limited to workers directly involved in handling cylinders. Under accident conditions, the health and safety of both workers and members of the general public around the sites could potentially be affected.

5.1.1.1 Normal Facility Operations

5.1.1.1.1 Workers

Cylinders containing depleted UF_6 emit low levels of gamma radiation. Involved workers would be exposed to this radiation when working near cylinders, such as during routine cylinder monitoring and maintenance activities, cylinder relocation and painting, and when patching or repairing cylinders. It was estimated that a total of about 60 cylinder yard workers (on average) would be required at the three current storage sites (30 at Paducah, 16 at Portsmouth, and 13 at K-25). These workers would be trained to work in a radiation environment, they would use protective equipment as necessary, and their radiation exposure levels would be measured and monitored by safety personnel at the sites. Radiation exposure of workers is required by law to be maintained ALARA.

The radiation exposure of involved workers (cylinder yard workers) in future years through 2039 was estimated to be well within public health standards (10 CFR Part 835). If the same 60 workers conducted all cylinder management activities, the average annual dose to individual involved workers was estimated to be about 740 mrem/yr at Paducah, 600 mrem/yr at Portsmouth, and 410 mrem/yr at K-25. Worker doses are required by health regulations to be maintained below 5,000 mrem/yr (10 CFR Part 835). The estimated future doses did not account for standard ALARA practices that would be used to keep the actual doses as far below the limit as practicable. Thus, the future doses to workers would be expected to be less than those estimated because of the conservatism in the assumptions and models used to generate the estimates. In fact, from 1990 through 1995, the average measured doses to cylinder yard workers ranged from about 16 to 56 mrem/yr at Paducah, 55 to 196 mrem/yr at Portsmouth, and 32 to 92 mrem/yr at K-25 (Hodges 1996). For comparison, radiation doses from background radiation and some common activities are given in Table 4.4.

The total dose to all involved workers at the three current storage sites from 1999 through 2039 was estimated to be about 1,500 person-rem (the dose to noninvolved workers is negligible [i.e., less than 1%] compared to the dose to involved workers). This dose would be distributed among all of the workers involved with cylinder activities over the 41-year period. About 60 workers would be required each year; however, the number of different individuals involved over the period would probably be much greater than this because workers could be rotated to different jobs and could change jobs. This level of exposure was estimated to potentially result in about 1 LCF among all the workers exposed, in addition to the cancer cases that would result from all other causes.

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations are not expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, they would be provided with appropriate protective equipment as necessary. The potential chemical exposures of noninvolved workers from any airborne releases during normal operations were estimated to be below levels expected to cause adverse effects (the hazard indices were estimated to be less than 0.002 for noninvolved workers at all three sites).

5.1.1.1.2 General Public

Potential health impacts to members of the general public could occur if material released from breached cylinders entered the environment and was transported from the sites through the air, surface water, or groundwater. Off-site releases of uranium and HF are possible from breached cylinders. However, the predicted off-site concentrations of these contaminants in the future were estimated to be much less than levels expected to cause adverse effects. Potential exposures of members of the general public would be well within public health standards. No adverse effects (LCFs or chemical effects) were estimated to occur among the general public residing within 50 miles (80 km) of each site from depleted UF_6 management activities.

If all the uranium and HF assumed to be released from breached cylinders through 2039 were dispersed from the sites through the air, the total radiation dose to the general public (all persons within 50 miles [80 km]) was estimated to be less than 0.38 person-rem over the period 1999 through 2039 (all three sites combined). This level of exposure would most likely result in zero cancer fatalities among members of the general public. For comparison, the average radiation dose from natural background radiation to a single person in 1 year is about 0.36 person-rem (360 mrem). The maximum radiation dose to an individual near any one of the sites was estimated to be less than about 0.2 mrem/yr, well within health standards. Radiation doses to the general public are required by health regulations to be maintained below 10 mrem/yr from airborne sources (40 CFR Part 61) and below a total of 100 mrem/yr from all sources combined (DOE Order 5400.5). If an individual were to receive the maximum estimated dose every year (1999–2039), the total dose would be about 8 mrem, resulting in an additional chance of dying from a latent cancer of about 1 in 200,000. No noncancer health effects from exposure to airborne uranium and HF releases would be expected — the estimated hazard index for a maximally exposed individual was estimated to be less than 0.1 at all three sites. This means that the total exposure would be at least 10 times less than exposure levels that might cause adverse effects.

The material released from breached cylinders could also potentially be transported from the sites in water, either in surface water runoff or by infiltrating the soil and contaminating groundwater. Members of the general public potentially could be exposed if this contaminated surface water or groundwater were used as a source of drinking water. The results of the surface water and groundwater analyses indicate that the maximum estimated uranium concentrations in surface water accessible to the general public and in groundwater beneath the sites would be less than the proposed EPA drinking water standard of 20 µg/L (EPA 1996) used as a guideline at all three sites (see Sections 5.1.4.1 and 5.1.4.2, respectively). Drinking water standards, meant to apply to water "at the tap" of the user, are set at levels protective of human health.

If a member of the public were to use contaminated water at the maximum concentrations estimated, adverse effects would be unlikely. Assuming a member of the general public used contaminated surface water or groundwater as their primary water source, the maximum radiation dose in the future was estimated to be less than 0.5 mrem/yr at each site. The corresponding risk to this individual of dying from a latent cancer would be less than 1 in 1 million per year. Noncancer health effects from exposure to possible water contamination would not be expected — the estimated hazard index for an individual assumed to use the groundwater was less than 0.2. This means that the total exposure would be 5 times less than the exposure that might cause adverse effects.

If no credit is taken for reduced cylinder corrosion rates from cylinder maintenance and painting activities, the groundwater analysis indicates that the uranium concentration in groundwater at the three sites could exceed 20 μg/L sometime in the future (see Section 5.1.4.2). In such a case, mitigative measures, such as treatment of the water or supplying an alternative source of water, might be required to ensure the safety of those potentially using the water.

5.1.1.2 Facility Accidents

5.1.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 people in the United States were killed in accidents while at work, and approximately 3.5 million work-related injuries were reported (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured under the no action alternative, unrelated to any radiation or chemical exposures.

The numbers of accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated. The estimates were based on the number of workers required over this period and on the historical accident fatality and injury rates in similar types of industries (see Appendix D, Section D.2). It was estimated that a total of about 0.1 accidental fatality (about 1 chance in 10 of a single fatality) might occur at the three sites over the 41-year period. Similarly, a total of about 140 accidental injuries (defined as injuries resulting in lost workdays) was estimated at the three sites combined. These rates would not be unique to the activities required for the no action alternative, but would be typical of any industrial project of similar size and scope.

5.1.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the no action alternative, accidents are possible that could release radiation and chemicals from cylinders. A wide range of different types of accidents was evaluated at each of the three current storage sites. The accidents included those initiated by operational events, such as equipment or operator failure; external hazards, such as aircraft crashes; and natural phenomena, such as earthquakes. The assessment considered accidents ranging from those that would be reasonably likely to occur (one or more times in 100 years on average) to those that would be extremely rare (estimated to occur less than once in 1 million years on average).

The accidents of most concern at the sites are accidents that could cause a release of UF_6 from cylinders. In a given accident, the amount potentially released would depend on the severity of the accident and the number of cylinders involved. Following a release, the UF_6 could combine with moisture in the air, forming gaseous HF and uranyl fluoride, a soluble solid in the form of small particles. The depleted uranium and HF could be dispersed downwind, potentially exposing workers and members of the general public living near the sites to radiation and chemical effects. The workers considered in the accident assessment were those noninvolved workers not immediately in the vicinity of the accident; fatalities and injuries among involved workers are possible for severe accidents (see Section 4.3.2.1).

The estimated consequences of cylinder accidents are summarized in Table 5.1 for chemical effects and in Table 5.2 for radiation effects. The impacts are the maximums estimated for any of the three current storage sites (site-specific impacts are presented in Appendix D). The impacts are presented separately for accidents considered likely and for those rare, low-probability accidents that were estimated to result in the largest potential impacts. Although other accidents were evaluated (see Appendix D, Section D.2.2), the estimated consequences of other accidents at all three sites would be less than those summarized in the tables. The estimated consequences are conservative in nature because they were based on the assumption that the wind would be blowing in the direction of the greatest number of people at the time of the accident and that weather conditions would limit dispersion in the air, so that high concentrations would occur. In addition, the effects of protective measures, such as evacuation, were not considered.

Chemical Effects. The potential likely accident (defined as an accident that is estimated to occur one or more times in 100 years) that would cause the largest chemical health effects is the failure of a corroded cylinder spilling part of its contents under dry weather conditions. Such an accident could occur, for example, during cylinder handling activities. It was estimated that about 24 lb (11 kg) of UF_6 could be released in such an accident. The potential consequences from this type of accident would be limited to on-site workers. The off-site concentrations of HF and uranium were calculated to be less than the levels that would cause adverse effects from exposure to these chemicals, so that zero adverse effects were estimated to occur among members of the general public. If this accident did occur, it was estimated that up to 70 noninvolved workers might experience potential adverse effects from exposure to HF and uranium (mostly mild and transient effects, such as respiratory irritation or temporary decrease in kidney function). It was estimated that 3 noninvolved workers might experience potential irreversible adverse effects (such as lung or kidney damage). The number of fatalities following an HF or uranium exposure is expected to be somewhat less than 1% of the number of potential irreversible adverse effects (Policastro et al. 1997). Therefore, no fatalities would be expected. In nearly 40 years of cylinder handling activities, no accidents involving releases from cylinders containing solid UF_6 have occurred that have caused diagnosed irreversible adverse effects among workers.

For assessment purposes, the estimated frequency of a corroded cylinder spill accident was assumed to be about once in 10 years. Therefore, over a 41-year period, about four such accidents

TABLE 5.1 Estimated Consequences of Chemical Exposures for Accidents under the No Action Alternative[a]

Receptor[b]	Accident Scenario	Site	Accident Frequency Category[c]	Effect[d]	Consequence[e] (persons affected)
			Likely Accident(s)		
General public	Corroded cylinder spill, dry conditions	All sites	L	Adverse effects	0
	Corroded cylinder spill, dry conditions	All sites	L	Irreversible adverse effects	0
	Corroded cylinder spill, dry conditions	All sites	L	Potential fatalities	0
Noninvolved Workers	Corroded cylinder spill, dry conditions	K-25	L	Adverse effects	70
	Corroded cylinder spill, dry conditions	K-25	L	Irreversible adverse effects	3
	Corroded cylinder spill, dry conditions	K-25	L	Potential fatalities	0
			Low Frequency-High Consequence Accident(s)		
General public	Vehicle-induced fire, 3 full 48G cylinders	Paducah	EU	Adverse effects	1,900
	Corroded cylinder spill, wet conditions – water pool	Portsmouth	EU	Irreversible adverse effects	1
	Corroded cylinder spill, wet conditions – water pool	Portsmouth	EU	Potential fatalities	0
Noninvolved Workers	Vehicle-induced fire, 3 full 48G cylinders	Portsmouth	EU	Adverse effects	1,000
	Corroded cylinder spill, wet conditions – water pool	Paducah	EU	Irreversible adverse effects	300
	Corroded cylinder spill, wet conditions – water pool	Paducah	EU	Potential fatalities	3

[a] The accidents listed are those estimated to result in the greatest impacts among all the accidents considered at all three sites. The site-specific impacts for a range of accidents at each of the three current storage sites are listed in Appendix D. The consequences are different at each site because of differences in the worker and public population distributions around the sites.

[b] Noninvolved workers are persons working at the site but not involved in handling of materials. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/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).

[d] Potential adverse effects include exposures that could result in mild and transient injury, such as respiratory irritation. Potential irreversible adverse effects include exposures that could result in permanent injury (e.g., impaired organ function) or death. The majority of the adverse effects would be mild and temporary in nature. It is estimated that less than 1% of the predicted potential irreversible adverse effects would result in fatalities (see text).

[e] The consequence is expressed as the maximum number of individuals with a predicted exposure level sufficient to cause the corresponding health endpoint. The estimated consequences were based on the assumption that the meteorological conditions would be F stability with 1 m/s wind speed, considered to be the worst conditions, and that the wind would be blowing in the direction of the highest worker or public population density.

TABLE 5.2 Estimated Consequences from Radiation Exposures for Accidents under the No Action Alternative[a]

				MEI		Population	
Receptor[b]	Accident Scenario	Site	Accident Frequency Category[c]	Dose (rem)	Lifetime Risk of LCF	Dose (person-rem)	Number of LCFs
			Likely Accident(s)				
General public	Corroded cylinder spill, dry conditions	K-25	L	0.003	1×10^{-6}	0.43	0.0002
Noninvolved Workers	Corroded cylinder spill, dry conditions	Portsmouth	L	0.077	3×10^{-5}	2.2	0.0008
			Low Frequency-High Consequence Accident(s)				
General public	Vehicle-induced fire, 3 full 48G cylinders	Paducah	EU	0.015	7×10^{-6}	28	0.01
Noninvolved Workers	Vehicle-induced fire, 3 full 48G cylinders	K-25	EU	0.02	8×10^{-6}	16	0.006

[a] The accidents listed are those estimated to have the greatest impacts among all accidents considered at all three sites. The impacts for a range of accidents at each of the three current storage sites are listed in Appendix D. The estimated consequences were based on the assumption that the wind would be blowing in the direction of the highest worker or public population density and that weather conditions limited dispersion.

[b] Noninvolved workers are persons working at the site but not involved in handling of materials. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/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).

would be expected. The accident risk (defined as consequence times probability) would be about 280 workers with potential adverse effects and 12 workers with potential irreversible adverse effects over the period 1999 through 2039. The number of workers actually experiencing these effects would probably be considerably less, depending on the actual circumstances of the accidents and the individual chemical sensitivity of the workers. In previous accidental exposure incidents involving liquid UF_6 in gaseous diffusion plants, a few workers have been exposed to amounts of uranium estimated to be approximately three times the guidelines used for assessing irreversible adverse effects in this PEIS, and none actually experienced irreversible adverse effects (McGuire 1991).

Accidents that are less likely to occur could have higher consequences. The potential cylinder accident at any of the sites estimated to result in the greatest total number of adverse chemical effects is an accident involving three cylinders in a fire caused by an on-site vehicle accident (although more cylinders than three might be affected by a fire, three was the most likely number based on estimates of the fuel available from a truck). If this accident occurred, it was estimated that up to 1,900 members of the general public and 1,000 noninvolved workers might experience adverse effects from HF and uranium exposure (mostly mild and transient effects, such as respiratory irritation or temporary decrease in kidney function). This accident is considered extremely unlikely, estimated to occur between once in 10,000 years and once in 1 million years. If the frequency is assumed to be once in 100,000 years, the accident risk over the period 1999 through 2039 would be less than 1 adverse effect for both workers and members of the general public.

The potential cylinder accident estimated to result in the largest total number of irreversible adverse effects is a corroded cylinder spill under wet conditions, where the UF_6 was assumed to be released into a pool of standing water. This accident is also considered extremely unlikely, expected to occur between once in 10,000 years and once in 1 million years. If this accident occurred, it was estimated that about 1 member of the general public and 300 noninvolved workers might experience irreversible adverse effects from HF and uranium exposure (such as lung damage). The number of fatalities would be somewhat less than 1% of the estimated number of potential irreversible adverse effects (Policastro et al. 1997). Thus, no fatalities would be expected among the general public, although 3 fatalities could occur among noninvolved workers (1% of 300). If the frequency of this accident is assumed to be once in 100,000 years, the accident risk over the period 1999 through 2039 would be less than 1 (0.1) irreversible adverse health effect among workers and the general public, combined.

Radiation Effects. Potential cylinder accidents could release uranium, which is radioactive in addition to being chemically toxic. The potential radiation exposures of members of the general public and noninvolved workers were estimated for the same cylinder accidents discussed for chemical effects (Table 5.2). For all cylinder accidents considered, the radiation doses from released uranium were estimated to be considerably below levels likely to cause radiation-induced effects among noninvolved workers and the general public, and below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents.

For the corroded cylinder spill accident (dry conditions), the radiation dose to a maximally exposed member of the general public at any of the sites was estimated to be less than 3 mrem (lifetime dose), resulting in an increased risk of death from cancer of about 1 in 1 million. The total population dose to the general public within 50 miles (80 km) was estimated to be less than 1 person-rem, most likely resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be 77 mrem, resulting in an increased risk of death from cancer of about 1 in 30,000. The total dose to all noninvolved workers was estimated to be about 2.2 person-rem. This dose to workers was estimated to result in zero LCFs. The risk (consequence times probability) of additional LCFs among members of the general public and workers combined would be much less than 1 over the period 1999 through 2039.

The cylinder accident estimated to result in the largest potential radiation doses would be the accident involving three cylinders in a fire. For this accident, the radiation dose to a maximally exposed member of the general public was estimated to be about 15 mrem, resulting in an increased risk of death from cancer of about 1 in 150,000. The total population dose to the general public within 50 miles (80 km) was estimated to be 28 person-rem, most likely resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be about 20 mrem, resulting in an increased risk of death from cancer of about 1 in 100,000. The total dose to all noninvolved workers was estimated to be about 16 person-rem. This dose to workers was estimated to result in zero LCFs. The risk (consequence times probability) of additional LCFs among members of the general public and workers combined would be much less than 1 over the period 1999 through 2039.

5.1.2 Transportation

Continued cylinder storage under the no action alternative would potentially generate small amounts of LLW and LLMW during cylinder monitoring and maintenance activities. This material could require transportation to a treatment or disposal facility. Shipments would be made in accordance with all DOE and DOT regulations and guidelines. It was estimated that less than one waste shipment would be required each year. Because of the small number of shipments and the low concentrations of contaminants expected, the potential environmental impacts from these shipments would be negligible (see Appendix J).

5.1.3 Air Quality

Potential impacts to air quality for the no action alternative considered air pollutant emissions from continued cylinder storage activities, including construction of new yards (engine exhaust and particulate matter emissions [i.e., dust]), operations (cylinder painting and vehicle emissions), and HF emissions from breached cylinders. Atmospheric dispersion models were used to estimate the concentrations of criteria pollutants at the site boundaries. Criteria pollutants are those that have corresponding federal air quality standards — hydrocarbons (HC), CO, NO_x, sulfur oxides (SO_x), Pb, and PM_{10}. The site boundary concentrations were compared with existing air quality standards or with guidelines for pollutants that do not have corresponding standards. These standards and guidelines are given in Chapter 3. For the no action alternative, estimated concentrations of criteria pollutants and HF were all within applicable standards and guidelines. However, because potential PM_{10} emissions during construction activities were estimated to be very close to the standards, procedures to reduce these emissions might have to be implemented during construction.

In general, the highest levels of criteria pollutants would be generated by construction activities occurring at the Paducah and K-25 sites. Except for PM_{10}, the air concentrations of all criteria pollutants resulting from no action alternative activities would be less than 3% of the respective standards. Particulate matter emissions from construction could result in maximum 24-hour average PM_{10} concentrations just below the standards (about 90 to 95% of the standard value of 150 $\mu g/m^3$), although the estimated annual average concentrations would be lower (about 30 to 55% of the standard value of 50 $\mu g/m^3$). During actual construction, mitigative measures would be taken to reduce the generation of particulate matter, such as spraying the soil with water and covering the excavated soil. Such measures are commonly employed during construction but were not accounted for in the modeling done for the PEIS analysis. Currently planned construction activities for the no action alternative are limited to the first few years of operations (through 2002).

Operations activities would emit much lower concentrations of criteria pollutants than would construction activities (all lower than 0.3% of standards). Painting activities could generate hydrocarbon emissions. There is no explicit air quality standard for hydrocarbon emissions, but these emissions are associated with ozone formation. For each of the three current cylinder storage sites, hydrocarbon emissions from painting activities would be less than 1.2% of the hydrocarbon emissions from the entire surrounding county. Because ozone formation is a regional issue affected by emissions for an entire area, these small additional contributions to the county totals would be unlikely to substantially alter the ozone levels of the county.

Estimated annual average site boundary concentrations of HF from hypothetical cylinder breaches occurring under the no action alternative ranged from 0.01 to 0.08 $\mu g/m^3$ for the three sites. The States of Kentucky and Tennessee have HF air standards, whereas no federal or State of Ohio standards exist. The annual average HF concentration for the Paducah site was estimated to be less than 0.002% of the standard. The estimated maximum 24-hour average HF concentration for the K-25 site is 0.67 $\mu g/m^3$, which is about 23% of the State of Tennessee 24-hour average standard for HF (the HF standards for Tennessee are much lower than those for Kentucky).

If no credit is taken for corrosion reduction through painting and continued maintenance, and if storage is continued at the three current storage sites indefinitely, calculations indicate that breaches occurring at the K-25 site by around the year 2020 could result in maximum 24-hour average HF concentrations at the site boundaries equal to approximately 2.9 $\mu g/m^3$ (3.5 parts per billion [ppb]) (Tschanz 1997b). This level corresponds to the primary standard for the State of Tennessee. For comparison, the maximum estimated 24-hour average HF concentrations at the Paducah and Portsmouth sites through the year 2039 were estimated to be 2 and 0.6 $\mu g/m^3$, respectively. (The State of Kentucky primary standard for HF maximum 24-hour average is much higher, 800 µg/m^3; the State of Ohio does not have ambient air quality standards for HF.) Because of the ongoing painting and maintenance program, it is not expected that breaches occurring prior to 2039 would be sufficient to increase the HF concentrations above the applicable standards at any of the sites (Tschanz 1997a).

5.1.4 Water and Soil

Potential impacts on surface water, groundwater, and soil could occur during continued storage of the cylinders under the no action alternative. Important elements in assessing potential impacts for surface water include changes in runoff, floodplain encroachment, and water quality. Groundwater impacts were assessed in terms of changes in recharge to the underlying aquifers, depth to groundwater, direction of groundwater flow, and groundwater quality. Potential soil impacts considered were changes in topography, permeability, erosion potential, and soil quality.

For the no action alternative, very limited construction activity is planned, and that planned activity would occur in previously developed areas. Water use and waste water discharge would also be very limited. Therefore, the assessment area in which potentially important impacts might occur was determined to be quality of surface water, groundwater, and soil. The other potential impacts would all depend on changes in permeable land areas at the sites due to construction activities or on water use and effluent volumes.

The contaminant of concern for evaluating surface water, groundwater, and soil quality is uranium. Surface water and groundwater concentrations of contaminants are generally evaluated through comparison with the EPA MCLs, as given in *Safe Drinking Water Act* regulations (40 CFR Part 141), although these limits are only directly applicable “at the tap” of the water user. The proposed MCL for uranium is 20 µg/L (EPA 1996); this value has been used as a guideline for evaluating surface water and groundwater concentrations of uranium in this PEIS, although it is not directly applicable as a standard. There is also no standard available for limiting concentrations of uranium in soil; a health-based value of 230 µg/g (EPA 1995a), applicable for residential settings, has been used as a guideline for comparison in this PEIS.

The nearest surface waters to the current storage sites are Little Bayou Creek, Little Beaver Creek, and Poplar Creek for the Paducah, Portsmouth, and K-25 sites, respectively. These surface waters are tributaries to larger rivers at each of the sites; the larger rivers are used as drinking water sources. Because of very large dilution effects, even very high levels of contaminants in the nearest site surface waters would not be expected to cause levels exceeding guidelines at the drinking water intakes of the larger rivers.

Water use during construction activities would be 2 million and 0.8 million gal for the Paducah and K-25 sites, respectively. Maximum water use during operations would be 160,000, 60,000, and 32,000 gal/yr for the Paducah, Portsmouth, and K-25 sites, respectively.

5.1.4.1 Surface Water

Potential impacts on the nearest receiving water at each site (i.e., Little Bayou Creek, Little Beaver Creek, and Poplar Creek) were estimated for uranium released from hypothetical cylinder breaches occurring through 2039. The estimated maximum concentrations of uranium in these receiving waters were 0.3, 0.7, and 0.02 µg/L for the Paducah, Portsmouth, and K-25 sites, respectively. These concentrations are considerably below the 20 µg/L level used for comparison.

5.1.4.2 Groundwater

Potential impacts on groundwater quality from hypothetical releases of uranium from breached cylinders were also assessed. The maximum future concentrations of uranium in groundwater directly below the sites were estimated to be 6, 5, and 7 µg/L for the Paducah, Portsmouth, and K-25 sites, respectively. Assuming a rapid rate of uranium migration, these concentrations were estimated to occur sometime after the year 2070. Lower concentrations would occur if uranium migration through the soil was slower. The groundwater concentrations at all three sites were estimated to be considerably below the 20 µg/L level used for comparison.

Groundwater in the vicinity of the Paducah and Portsmouth sites is used for domestic and industrial supplies. Groundwater in the vicinity of the K-25 site discharges to nearby surface waters and is not known to be used as a domestic or industrial source. (See Chapter 3 for a discussion of existing groundwater quality at each of the sites.) At Paducah, a municipal water supply has been supplied by the Paducah site to residents having wells within an area of groundwater contaminated with trichloroethylene and technetium-99. At Portsmouth, sampling results indicate that residential water supplies have not been affected by site operations. Activities associated with the no action alternative would not affect migration of existing groundwater contamination or off-site water supplies.

If no credit is taken for corrosion reduction through cylinder painting and maintenance, and if storage is continued at the three current storage sites indefinitely, calculations indicate that uranium releases from future cylinder breaches occurring at the Paducah site prior to about the year 2020 could result in a sufficient amount of uranium in the soil column to increase the groundwater concentration of uranium to 20 µg/L in the future (about 2100). The cylinders would have to undergo uncontrolled corrosion (without painting and maintenance) until about 2050 at the Portsmouth site and until about 2025 at the K-25 site before the same groundwater concentration guideline of 20 µg/L would be a concern. The groundwater concentration would not actually reach 20 µg/L at these sites until about 2100 or later. Because of the ongoing painting and maintenance program, it is not expected that breaches occurring prior to 2039 would be sufficient to increase the groundwater concentration to 20 µg/L at any of the sites.

5.1.4.3 Soil

Potential impacts on soil that could receive contaminated rainwater runoff from the cylinder storage yards were estimated. The source was assumed to be uranium released from hypothetical breached cylinders. The estimated maximum soil concentrations were 1, 1, and 3 µg/g for the Paducah, Portsmouth, and K-25 sites, respectively. These concentrations are considerably below the 230 µg/g guideline used for comparison.

5.1.5 Socioeconomics

The potential socioeconomic impacts of construction and operational activities under the no action alternative would be low. Construction activities at the Paducah and K-25 sites would create short-term employment (30 direct jobs, 110 total jobs in the peak construction year); operational activities occurring at the three sites would create 110 direct jobs and 210 total jobs per year. Direct and total income from construction in the peak year would be $1.4 million and $3.5 million, respectively. During operations, direct and total income would be $5.1 million/yr and $6.7 million/yr, respectively.

The employment and income created in the ROIs for the three sites would represent a change of less than 0.005% of projected growth in these indicators of overall regional activity. The in-migration expected into each region with each activity would have only a low impact on regional population growth rates and would require less than 2% of vacant housing stock at each of the three sites. No significant impacts on local public finances would be expected.

5.1.6 Ecology

The no action alternative would have a negligible impact on ecological resources in the area of the three current storage sites. Very limited construction activity is planned, and the planned activities would all occur in previously developed areas. Thus, impacts on wetlands and federal- and state-protected species due to facility construction would also be negligible.

The assessment results indicate that impacts to ecological resources from facility operations would be negligible. Analysis of potential impacts was based on exposure of biota to airborne contaminants or contaminants released to soil, groundwater, or surface water. Predicted concentrations of contaminants in environmental media were compared to benchmark values of toxic and radiological effects (see Appendix C, Section C.3.3). At all three sites, soil, groundwater, and surface water concentrations would be considerably below levels harmful to biota.

5.1.7 Waste Management

Under the no action alternative, construction and operations at the current storage sites would generate relatively small amounts of LLW and LLMW. The volume of LLW generated by continued storage activities would represent less than 1% of the annual generation at each of the three sites.

The maximum annual amount of LLMW generation from stripping/painting operations at the Paducah site would generate about 20% of the site's total annual LLMW load, constituting a potential moderate impact on LLMW management. LLMW generation for the Portsmouth and K-25 sites would be less than 1% of site LLMW generation, resulting in negligible waste management impacts for these sites. The total volume of LLMW generated at all three sites would also be less than 1% of the projected annual DOE LLMW treatment volume (i.e., 68,000 m^3/yr; see Appendix C, Section C.10), so that the overall impact on waste management operations from the no action alternative would be negligible to low.

5.1.8 Resource Requirements

Construction and operation of facilities under the no action alternative would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that are generally irretrievable resources. The total quantities of commonly used materials would be small compared to local sources and would not affect local, regional, or national availability of these materials. No strategic or critical materials are projected to be consumed during construction or operations. The anticipated utilities requirements would be within the supply capacities at each site. The required material resources during construction and operations at all three sites would be readily available.

5.1.9 Land Use

Very limited construction activity is planned under the no action alternative. For the Paducah site, only reconstruction of storage yards within the boundaries of existing yards is planned, so additional land clearing would not be necessary. For the K-25 site, construction of a new storage yard with an area of approximately 6.7 acres (2.7 ha) is planned, but this yard is expected to be located in an area already dedicated to similar use. No new construction is planned for the Portsmouth site. Therefore, impacts of the no action alternative with respect to land use would be none or negligible.

5.1.10 Cultural Resources

Under the no action alternative, impacts to cultural resources would not be likely at the Paducah or Portsmouth sites during continued cylinder storage. (See Chapter 3 for a discussion of cultural resources existing at the three storage sites.) The existing storage yards at Paducah are located in previously disturbed areas unlikely to contain cultural properties or resources listed on or eligible for the *National Register of Historic Places*. No new storage yards are proposed at Portsmouth, so no cultural resources would be affected. A new storage yard is proposed at the K-25 site; although the exact location of the yard is unknown, it would probably be located in an area already dedicated to similar use.

5.1.11 Environmental Justice

A review of the potential human health and safety impacts occurring under the no action alternative indicates that no disproportionately high and adverse effects to minority or low-income populations would be expected in the vicinity of the three current storage sites during normal operations. Although such populations reside within 50 miles (80 km) of the sites (see Appendix C), no disproportionate impacts would be expected. The results of accident analyses for the no action alternative also did not identify high and adverse impacts to the general public (i.e., the risk of accidents, consequence times probability, was less than one fatality for all accidents considered).

5.2 LONG-TERM STORAGE AS UF_6

Under the long-term storage as UF_6 alternative, the depleted UF_6 inventory was assumed to be stored in cylinders at a consolidated storage site through 2039. Three options were considered for the long-term storage of cylinders: storage in yards (similar to those currently used), storage in buildings, and storage in an underground mine (see Appendix G). To provide a conservative estimate of potential impacts, it was assumed that long-term storage would take place at a newly constructed, independent facility and that cylinders would be transported from the three current storage sites by either truck or rail.

The following is a summary of the activities analyzed under the long-term storage as UF_6 alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage was assumed to continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped off-site to a consolidated storage facility. The cylinder management activities that would occur at the sites were assumed to be similar to those for the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** In the future, a number of cylinders might not be suitable for transportation and might thus require some type of preparation prior to off-site shipment (see Section 4.2 and Appendix E). Two cylinder preparation options were considered for these cylinders: (1) a cylinder overcontainer option and (2) a cylinder transfer option. The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three sites. Preoperations for transfer facilities were assumed to occur between 1999 and 2008 (with actual construction requiring 4 years). Operations would occur between 2009 and 2028. Cylinder preparation impacts were evaluated for a range in the number of cylinders prepared at each site (as summarized in Section 4.2.2).

- ***Long-Term Storage (Representative Site).*** The three long-term storage options considered are storage in yards, storage in buildings, and storage in an underground mine (see Appendix G). Cylinders would be received at the storage facility from 2009 through 2028. Construction activities would also be ongoing from 2009 through 2028. Monitoring and maintenance were evaluated through 2039.

- ***Transportation (Representative Routes).*** All cylinders were assumed to be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to an independent long-term storage site.

Under the long-term storage as UF_6 alternative, the cylinder management activities at the current storage sites were assumed to be similar to those that would occur under the no action alternative, including cylinder painting. However, because of impending cylinder movement or content transfer, cylinder yard improvement and cylinder painting might not occur at the same rate as they would under the no action alternative. Because the painting schedule that would be followed under the action alternatives (including long-term storage as UF_6) is not known, and to present reasonable upper bound estimates of impacts, no credit was taken for the effectiveness of cylinder yard improvements and painting in reducing cylinder corrosion rates. The number of hypothetical breached cylinders at the three current storage sites was estimated by assuming historical corrosion rates. Therefore, for analytical purposes, more cylinder breaches were assumed to occur under this alternative than under the base case for the no action alternative, even though the storage time at the current storage sites would be less.

5.2.1 Human Health and Safety

During implementation of the long-term storage as UF_6 alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. Potential impacts are discussed in Sections 5.2.1.1 and 5.2.1.2.

5.2.1.1 Normal Facility Operations

5.2.1.1.1 Workers

At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting, cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a long-term storage facility would be exposed to radiation during the placement of cylinders into long-term storage. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

Similar to the no action alternative, the radiation exposure of individual workers under the long-term storage as UF_6 alternative would be well within public health standards; average doses were estimated to be much less than the limit of 5,000 mrem/yr (10 CFR Part 835). The total radiation exposure of involved workers would be similar to, but slightly greater than, that under the no action alternative. The total exposure would be greater because of the additional cylinder handling required for preparation of cylinders for shipment and placement of cylinders into consolidated long-term storage. The estimated total number of potential radiation-induced LCFs among involved workers from 1999 through 2039 is summarized in Figure 5.1. (The totals include the radiation exposure during cleaning of empty cylinders that would be required if a cylinder transfer facility were used.) For all three storage options, about 1 additional LCF was estimated among the involved worker population, similar to the no action alternative. Impacts to noninvolved workers would be less than 1% of those to involved workers.

In addition to about 50 cylinder yard workers, 40 to 230 involved workers would be required under the long-term storage as UF_6 alternative (the exact number would depend on the cylinder preparation and storage options selected).

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations would not be expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, workers would be provided with appropriate protective equipment as necessary. The potential chemical exposure of noninvolved workers from airborne releases during normal operations was estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three sites and at a consolidated storage facility).

5.2.1.1.2 General Public

The potential impacts to members of the public during normal operations would be similar to those under the no action alternative — all exposures were estimated to be within applicable

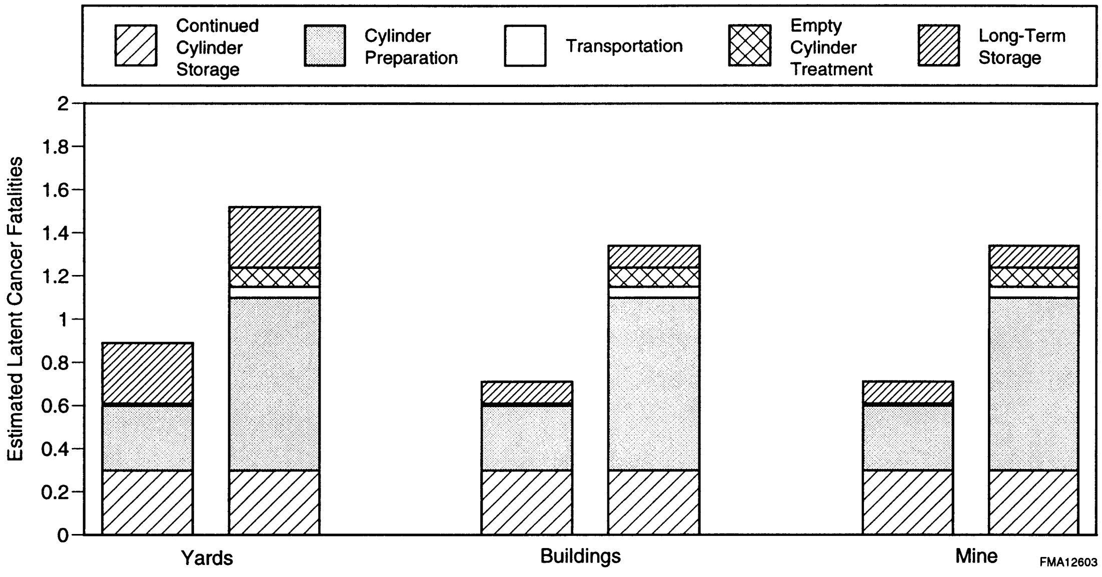

FIGURE 5.1 Total Estimated Number of LCFs among Involved Workers from Radiation Exposures during Normal Operations for the Long-Term Storage as UF_6 Alternative, 1999 through 2039 (Note: The two bars presented for each option represent the minimum and maximum impacts estimated.)

public health standards. No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites or near a consolidated long-term storage facility from depleted UF_6 management activities.

At the current storage sites, potential public exposures to radiation and chemicals were estimated to be slightly greater than under the no action alternative because, for the action alternatives, no credit was taken for reduced corrosion rates from cylinder painting and maintenance, resulting in an increased number of estimated cylinder breaches at the sites. However, the potential exposures of members of the general public were still estimated to be well within all applicable health standards and guidelines.

The total collective radiation dose to the general public around the three current storage sites from potential airborne emissions of uranium from breached cylinders was estimated to be about 1.1 person-rem over the period 1999 through 2028 (all cylinders were assumed to be removed by 2029). This level of exposure was estimated to result in zero LCFs among members of the general public. The maximum radiation dose to an individual near any of the sites was estimated to be less than 0.5 mrem/yr from airborne emissions, well within applicable health standards. Radiation doses to members of the general public are required by health regulations to be maintained below 10 mrem/yr from airborne sources (40 CFR Part 61) and below a total of 100 mrem/yr from all sources combined (DOE Order 5400.5). If an individual were to receive the maximum estimated dose every year (1999 through 2028), the total dose would be about 15 mrem, resulting in an chance of dying from a latent cancer of about 1 in 100,000. No noncancer health effects from exposure to airborne uranium and HF releases would be expected — the estimated hazard index for an individual was estimated to be less than 0.1 at all three sites. This means that the total exposure would be at least 10 times less than exposure levels that might cause adverse effects.

The results of the surface water and groundwater analyses indicate that the maximum estimated uranium concentrations would be less than the guideline level of 20 µg/L (EPA 1996) at all three sites. This is true even though a higher cylinder breach rate was assumed under the long-term storage as UF_6 alternative than under the no action alternative, because the cylinder inventory at the three sites would be steadily decreasing (see Sections 5.2.4.1 and 5.2.4.2). If a member of the general public near one of the sites were to use contaminated surface water or groundwater as a primary water source (at the maximum concentrations estimated to occur in the future), the annual radiation dose was estimated to be about 1 mrem/yr at all three sites. The corresponding chance of this individual dying from a radiation-induced latent cancer would be less than 1 in 1 million per year.

At a consolidated long-term storage site, cylinders would have undergone appropriate preparation at the current storage sites and would be inspected before being placed in storage. Once placed in storage, cylinders would be subjected to routine monitoring and maintenance activities similar to those occurring at the three current storage sites. If a breach occurred, storage in buildings or a mine would provide an additional level of containment when compared with yard storage. Consequently, impacts to members of the general public near a consolidated storage facility would be less than or equal to those discussed for the three current storage sites.

5.2.1.2 Facility Accidents

5.2.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related fatalities and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured during the long-term storage as UF_6 alternative, unrelated to any radiation or chemical exposures.

The number of accidental worker injuries and fatalities that might occur from 1999 through 2039 was estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries (see Appendix D, Section D.2). The estimated number of worker fatalities and injuries would be slightly greater than that under the no action alternative because of the additional construction and operational activities required for cylinder preparation and consolidated long-term storage facilities. It was estimated that a total of about 1 accidental fatality might occur over the 41-year period. Similarly, a total of between 240 and

900 accidental injuries was estimated. These rates would not be unique to the activities required for the alternative but would be typical of any industrial project of similar size and scope.

5.2.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the long-term storage as UF_6 alternative, accidents that could release radiation and chemicals from cylinders are possible. A wide range of different types of accidents was evaluated at the current storage sites during continued cylinder storage and cylinder preparation activities and at a consolidated long-term storage facility. The accidents at these facilities that could result in a release of radiation or chemicals would all involve cylinders, either while in storage or during handling.

The consequences of the potential cylinder accidents that could occur at the current storage sites under the long-term storage as UF_6 alternative would be the same as those described under the no action alternative (see Section 5.1.1.2.2). In addition, the consequences of cylinder accidents at a consolidated storage facility would also be the same as those discussed for the no action alternative because the types of accidents possible are the same, and, for assessment purposes, the environmental conditions of the three current storage sites were assumed to be representative of the conditions at a long-term storage facility.

5.2.2 Transportation

The major materials assumed to be transported under the long-term storage as UF_6 alternative are summarized in Table 5.3. To provide a conservative estimate of potential transportation impacts, it was assumed that all depleted UF_6 cylinders (46,422) would be transported from the three current storage sites to a consolidated long-term storage facility. All shipments would be made in accordance with applicable DOE and DOT regulations and guidelines. Transport by rail would require about 11,600 railcar shipments (with four cylinders per railcar), and transport by truck would require about 46,422 truck shipments (with one cylinder per truck). The operation of a cylinder transfer facility at each of the current storage sites would also produce waste, including LLW and LLMW, that would require shipment to a disposal facility. A total of about 600 truck shipments of radioactive waste would be required over the duration of the program. Because of the relatively small number of shipments and the low concentration of radioactive and chemical contaminants expected, the potential impacts associated with waste shipments were estimated to be negligible compared to those associated with the transportation of UF_6 cylinders. All shipments were assumed to take place over a 20-year period.

The assessment of transportation impacts considered truck and rail shipment options and evaluated impacts from both incident-free transportation operations as well as accidents. Because the location of a long-term storage site is unknown, for assessment purposes it was assumed that all

TABLE 5.3 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Long-Term Storage as UF_6 Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Consolidated long-term storage site	46,422	11,600[d]	2	1
LLW/LLMW	Current storage sites	Treatment/disposal site	520 - 640	–	0	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Colocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments when either the truck or rail mode is assumed to be used.

[c] Number of estimated traffic accident fatalities when each shipment is assumed to travel 620 miles (1,000 km) and national average accident statistics are used. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

shipments would travel a distance of 620 miles (1,000 km), primarily through rural areas but including some suburban and urban areas. The transportation assumptions and impacts for a range of shipment distances are discussed in detail in Appendix J. The transportation impacts could be reduced or eliminated by colocating facilities.

5.2.2.1 Normal Transportation (Incident-Free) Operations

During normal operations, radioactive materials and chemicals would be contained in their transport packages. Potential impacts would be possible from exposure to external radiation in the vicinity of cylinders and from exposure to vehicle engine exhaust emissions. Incident-free transportation operations were estimated to result in zero fatalities among workers and the general public, combined, for both truck and rail transportation. Members of the public living along truck and rail transportation routes were estimated to receive extremely small doses of radiation, much less than 0.1 mrem even if a single person were to be exposed to every shipment of radioactive material during the program.

5.2.2.2 Transportation Accidents

Transportation accidents could occur during the shipment of UF_6 cylinders. These accidents could potentially affect the health of workers (i.e., crew members) and members of the general public. Two types of accident impacts were estimated: (1) impacts from typical traffic accidents that could cause deaths from physical trauma, unrelated to the cargo being shipped, and (2) accidents that would involve the release of radioactive material or chemicals from a shipment.

5.2.2.2.1 Traffic Accidents with No Release

Shipments of cylinders and waste could be involved in truck or rail traffic accidents, with a chance that fatalities could result. To predict the number of traffic fatalities that might result from future shipments, historical traffic accident statistics were used. The estimated number of traffic fatalities depends on the total number of shipments, the shipment distance, the shipment mode (truck or rail), and the historical accident fatality rates.

The number of traffic fatalities estimated assuming the shipment of all 46,422 cylinders by truck or rail over a 20-year period are presented in Table 5.3 (for purposes of comparison, shipments were assumed to travel 620 miles [1,000 km]). If truck shipments were used, it was estimated that about 2 traffic fatalities could result. If rail shipments were used, it was estimated that about 1 traffic fatality could result. Rail transport results in a lower number of estimated traffic fatalities, primarily because railcars have a larger shipment capacity than trucks, resulting in fewer shipments. The estimated number of fatalities would be reduced if the number of shipments and shipment distances were reduced.

5.2.2.2.2 Traffic Accidents Involving Releases of Radiation or Chemicals

Traffic accidents that could cause a release of UF_6 from cylinders are possible. The amount released would depend on the severity of the accident and the number of cylinders involved. Following a release, the UF_6 would combine with moisture in the air, forming gaseous HF and UO_2F_2. The depleted uranium and HF would be dispersed downwind, potentially exposing members of the general public to radiation and chemical effects. The consequences of such a release would depend on the location of the accident and the weather conditions at the time. Potential consequences would be greatest in urban areas because more people could be exposed. Accidents that occurred when the weather was very stable (typical of nighttime conditions) would have greater potential consequences than accidents that occurred when the weather was unstable (i.e., turbulent, typical of daytime conditions) because the stability of the weather would determine how quickly the released material was dispersed and diluted to lower concentrations as it moved downwind.

Severe rail accidents could have higher consequences than truck accidents because each railcar would carry four cylinders, compared to one cylinder per truck. The accident estimated to have the largest potential consequences would be a severe rail accident involving four cylinders. The consequences of such an accident were estimated on the basis of the assumption that the accident occurred in an urban area under stable weather conditions (such as at nighttime). In such a case, it was estimated that approximately 4 persons might experience irreversible adverse effects (such as lung or kidney damage) from exposure to HF and uranium. The number of fatalities expected following an HF or uranium chemical exposure is expected to be somewhat less than 1% of the potential irreversible adverse effects. Thus, no fatalities would be expected (1% of 4). Over the long term, radiation effects are possible from exposure to the uranium released. In a highly populated urban area, it was estimated that about 3 million people could be exposed to small amounts of uranium as it was dispersed by the wind. Among those exposed, it was estimated that approximately 60 LCFs could occur in the urban population in addition to those occurring from all other causes. In a population of 3 million people, approximately 700,000 would be expected to die of cancer from all causes.

The occurrence of a severe rail accident breaching four cylinders in an urban area under stable weather conditions would be expected to be rare. The total probability of an urban rail accident involving a release (not taking into account the frequency of weather conditions) was estimated to be about 1 chance in 10,000 (8×10^{-5}) for shipping all the cylinders by rail over 20 years (the actual probability would depend on the route selected). The total accident risk from cylinder shipments was calculated by using the probability and consequences of the range of possible accident severities. The results indicate that zero fatalities from accidental radioactive and chemical releases would be expected over the 20-year shipment period (see Appendix J, Table J.6).

The consequences of cylinder accidents occurring in rural environments, during unstable weather conditions (typical of daytime) or involving a truck shipment, were also assessed. The consequences of all other accident conditions were estimated to be considerably less than those described above for the severe urban rail accident. These considerations are discussed further in Appendix J.

Although accidents involving shipments of LLW and LLMW could occur, the consequences of even the most severe accidents involving these materials would not be expected to cause any LCFs from radiation exposures or any irreversible adverse effects from exposure to chemicals if a release occurred.

5.2.3 Air Quality

The analysis of potential impacts to air quality for the long-term storage as UF_6 alternative considered the potential for air pollutant emissions from continued cylinder storage activities through 2028, cylinder preparation activities, and long-term storage activities at a consolidated site. The analysis of continued cylinder storage at the current sites considered construction of new yards, maintenance and operations, and HF emissions from breached cylinders, as described in Section 5.1.3. Estimated concentrations of criteria pollutants for continued storage activities were all within applicable standards and guidelines. However, because potential PM_{10} concentrations during construction activities were estimated to be close to the standards, procedures to reduce these emissions might have to be implemented during actual construction activities. In addition, the maximum 24-hour average HF concentrations at the K-25 site could be as high as 92% of the State of Tennessee standard for HF. This HF value is greater than that estimated under the no action alternative because, for the action alternatives, no credit was taken for reduced corrosion rates from cylinder painting and maintenance, thus resulting in an increased number of estimated cylinder breaches at the sites. Actual HF concentrations would be lower because improved cylinder storage conditions and painting activities are expected to reduce corrosion rates.

For construction activities that could occur as a part of cylinder preparation (i.e., if a transfer facility was constructed), estimated PM_{10} concentrations would also be within standards (62, 36, and 87% of the standards at Paducah, Portsmouth, and K-25, respectively). Procedures to reduce these emissions might have to be implemented during actual construction of a cylinder transfer facility. All other activities occurring as a part of cylinder preparation and consolidated storage facility construction and operations were estimated to result in criteria pollutant concentrations of less than 20% of standards. The analysis indicated that potential HF emissions from cylinder preparation and consolidated storage activities would be less than those estimated for continued cylinder storage at the current sites and thus would be within applicable standards.

5.2.4 Water and Soil

Water use from continued cylinder storage construction activities would range from 0.8 to 2 million gal. For operations, the water use would range from 32,000 to 160,000 gal/yr. The amounts of wastewater generated would be very small.

Construction activities for cylinder preparation would require from 6.5 to 10 million gal/yr (about 26 to 40 million gal total) of water if a transfer facility was constructed; operation of a transfer facility would require between 6 and 9 million gal/yr of water. Wastewater generated would be between 3 and 7 million gal/yr.

For consolidated storage in yards, buildings, or a mine, water use during construction would be between 0.5 and 6.4 million gal/yr; maximum water use during operations would be about 1.2 million gal/yr. Wastewater generation would be about 1.1 million gal/yr for all storage options.

5.2.4.1 Surface Water

Under the long-term storage as UF_6 alternative, potential impacts on surface water at the current storage sites could occur during continued storage of the cylinders through 2028. As for the no action alternative (Section 5.1.4), the only area with potentially important impacts was determined to be water quality. Impacts to the nearest receiving water at each site (Little Bayou Creek at

Paducah, Little Beaver Creek at Portsmouth, and Poplar Creek at K-25) were estimated for uranium released from hypothetical cylinder breaches occurring through 2028. The estimated maximum concentrations of uranium in receiving waters were estimated to be less than 2 µg/L for all three sites. These concentrations are considerably below the 20-µg/L guideline used for comparison. The water would then mix with water in the Ohio River, Scioto River, or Clinch River, resulting in even lower uranium concentrations.

Surface water impacts with respect to runoff and floodplain encroachment from cylinder preparation activities would be none to negligible (none for the cylinder overcontainer option; changes of less than 0.0006% in average river flows for the cylinder transfer facility option). Concentrations of uranium released in wastewater would be very low and would result in concentrations much lower than 20 µg/L in the surface waters to which wastewaters would be released.

For consolidated storage of UF_6 cylinders, the changes in average river flows for the representative sites would be less than 0.0001%, so impacts to runoff and floodplain encroachment, although dependent on the actual site location, would probably be negligible. Concentrations of uranium released in wastewater would be very low and would result in concentrations much lower than 20 µg/L in the surface waters to which wastewaters would be released.

5.2.4.2 Groundwater

Potential impacts on groundwater quality at the current storage sites from uranium releases due to hypothetical breached cylinders were assessed for continued storage through 2028; the maximum concentrations of uranium in groundwater beneath the sites were estimated to be 20, 4, and 9 µg/L for the Paducah, Portsmouth, and K-25 sites, respectively. These estimated concentrations would occur some time after the year 2070 and are based on the assumption of a rapid rate of uranium migration through the soil to the groundwater. Lower concentrations would occur if uranium migration through the soil was slower. Although the estimated groundwater concentration for Paducah is equal to the 20 µg/L guideline used for comparison, this is the maximum concentration estimated to occur and, because of conservatism in the calculations (e.g., the effects of cylinder painting in limiting corrosion were not considered), it is unlikely that groundwater concentrations would actually reach 20 µg/L at the Paducah site. Potential groundwater impacts would be mitigated by collecting and treating runoff from the cylinder yards and by identifying and repairing breached cylinders as soon as possible. (See Section 5.1.4 for a discussion of groundwater use in the vicinity of the three current storage sites.)

For cylinder preparation activities, impacts on depth to groundwater and flow direction would be none or negligible, depending on whether facility construction was required and whether groundwater or surface water was used during construction and operations. Good engineering and construction practices would be followed to minimize the potential for adverse impacts during construction. No releases to groundwater would occur during normal operations.

At a consolidated storage facility, the potential impacts to groundwater would depend on the actual facility location and on whether yards, buildings, or mines were used. Good engineering and construction practices would be followed to minimize the potential for adverse impacts during construction. If yards were used for storage, impacts would be less than those described for continued storage under the no action alternative because the cylinders in need of improvement would all have been subject to cylinder preparation (e.g., transferred to new cylinders) prior to consolidated storage. (Under the no action alternative, concentrations of uranium in groundwater from continued cylinder storage were estimated to be less than 5 µg/L.) No releases to groundwater were assumed to occur during normal operations under the building or mine storage options because rainwater would not come into contact with cylinders in buildings and mine storage was assumed to be in a dry environment.

5.2.4.3 Soil

Under the storage as UF_6 alternative, potential impacts to soil at the three current storage sites could occur during continued storage of the cylinders through 2028. As for the no action alternative (Section 5.1.4), impacts to soil receiving contaminated runoff from the cylinder storage yards were estimated by assuming the source to be uranium released from hypothetical breached cylinders. The estimated maximum soil concentration was 7 µg/g for the three current storage sites. This maximum soil concentration was higher than that calculated for the no action alternative because of conservatism in the calculations (e.g., the effects of cylinder painting in limiting corrosion were not considered). This concentration is well within the 230-µg/g guideline used for comparison.

For cylinder preparation activities, if a transfer facility were constructed at each of the current storage sites, from 0.4 to 0.7% of available land would be required. Even if this construction occurred on previously undisturbed land, which is unlikely, the impacts with respect to permeability and erosion potential would be negligible, and remaining unpaved areas would be returned to their former condition with regrading and reseeding.

At a consolidated storage facility, soil impacts would depend on whether yards, buildings, or a mine were the selected option and on the facility location. The impacts, which would tend to be temporary, would generally result from material excavated during construction that would be left on-site. The largest potential impacts on soil would occur for storage in a mine. Construction of a mine for storage could require excavating about 1.8 million yd^3 (1.4 million m^3) of consolidated material. In the short term, this amount of material would cause changes in site topography. In the long term, contouring and reseeding would return soil conditions back to their former state, and the impacts would be minor. If a previously existing mine were used for storage, excavation requirements could be significantly reduced and potential impacts to soils would be much less. Potential impacts to soil for yard and building storage facilities would be much less than storage in a mine.

5.2.5 Socioeconomics

The potential socioeconomic impacts of construction and operational activities would be low for continued storage at the current sites through 2028. Construction activities at the Paducah and K-25 sites would create short-term employment (30 direct jobs, 110 total jobs in the peak construction year); operational activities occurring at the three sites would create 120 direct jobs and 260 total jobs per year. Direct and total income from construction in the peak year would be \$1.4 million and \$3.5 million, respectively. During operations, direct and total income would be \$6 million/yr and \$7.9 million/yr, respectively. Differences from the no action alternative would be due to different painting schedules and different assumptions concerning the number of breached cylinders. Employment and income created would represent a change of less than 0.01% of projected growth in these indicators of overall regional activity. The in-migration expected into each region with each activity would have only a minor impact on regional population growth rates and would require less than 2% of vacant housing stock at each of the three sites. No significant impacts on local public finances would be expected.

The potential socioeconomic impacts of construction and operational activities for cylinder preparation at the current sites would also be minor. If the largest number of cylinders required overcontainers or transfer at the three sites, from 0 to 580 direct jobs and 0 to 960 total jobs would be created during preoperations (0 corresponds to use of overcontainers; the high end of the ranges corresponds to construction of transfer facilities at each site). Operational activities for cylinder preparation occurring at the three sites would create from 300 to 490 direct jobs and from 610 to 1,230 total jobs. Direct and total income from preoperations in the peak year would range from 0 to \$26 million and 0 to \$33 million, respectively. During operations, direct and total income would range from \$19 to \$25 million/yr and \$22 to \$37 million/yr, respectively. Employment and income created would represent a change of less than 0.04% of projected growth in these indicators of overall regional activity for any of the three sites. The in-migration expected into each region would have only a small impact on regional population growth rates and would generally require less than 5% of vacant housing stock at each of the three sites. (During the peak year of construction at the Paducah site, 10% of rental housing units could be required.) No significant impacts on local public finances would be expected.

The potential socioeconomic impacts of construction and operational activities at a consolidated storage facility would depend on the facility location and whether yards, buildings, or a mine were selected. Construction activities would create employment (100 to 500 direct jobs in the peak construction year); operational activities would create 50 to 60 direct jobs per year. Direct income from construction in the peak year would be from \$5 to \$29 million. During operations, direct income would be about \$3 million/yr. For long-term storage, construction and operations would be occurring concurrently over the 20-year emplacement period.

For the representative settings used for analysis, the employment and income created would represent a change of less than 0.02% of projected growth in these indicators of overall regional activity (see Appendix G, Section G.3.5). The in-migration expected into the region of a consolidated storage facility would have only a small impact on regional population growth rates. Negligible impacts on local public finances would be expected. The impacts of mine storage were calculated for a generic site; therefore, no estimates of indirect impacts on employment and income were made for mine options.

5.2.6 Ecology

The long-term storage of UF_6 cylinders at a consolidated facility could potentially impact ecological resources, primarily from construction. A very limited amount of construction activity is planned for continued storage at the current storage sites, and that planned would all occur in previously developed areas. Thus, impacts to wetlands and state and federally protected species due to facility construction would be negligible. Construction of a transfer facility at any of the three current storage sites would require at most up to 21 acres (11 ha), which would be expected to result in only moderate ecological impacts because of the large amounts of previously disturbed land at these sites. The construction of a long-term storage facility would disturb between 96 and 144 acres (38 to 58 ha), depending on the type of storage facility. Existing vegetation at the site would be destroyed during land-clearing activities. In addition, wildlife would be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the location of the facility; however, some permanent loss of habitat could result. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility location. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Impacts to ecological resources from facility operations at the current storage sites or a long-term storage site would be negligible to low. The concentrations of radioactive and chemical contaminants in air and water emissions would be considerably below levels considered harmful to vegetation and wildlife.

Facility and transportation accidents, as discussed in Sections 5.2.1 and 5.2.2, could result in adverse impacts to ecological resources. The affected species and degree of impact would depend on a number of factors, such as accident location, season, and meteorological conditions.

5.2.7 Waste Management

Under the long-term storage as UF_6 alternative, construction and operations for continued storage at the three current storage sites through 2028 would generate relatively small amounts of LLW and LLMW. The volume of LLW generated by continued storage activities would represent less than 1% of the annual generation at each of the three sites, and the total would be less than 1% of projected annual DOE LLW treatment volumes, indicating negligible impacts associated with LLW disposal. The maximum annual amount of LLMW generation from stripping/painting operations at the Paducah site would generate about 20% of the site’s total annual LLMW load, constituting a potential moderate impact on LLMW management. (The maximum annual LLMW generation amount is not decreased in comparison with the no action alternative, because most of the cylinder painting would occur in the early years of maintenance under both alternatives.) LLMW generation for the Portsmouth and K-25 sites would be less than 1% of site LLMW generation, resulting in negligible waste management impacts for these sites. The total volume of LLMW generated at all three sites would also be less than 1% of the total DOE LLMW load, so that overall waste management impacts from continued storage through 2028 would be negligible to small.

The waste management impacts from cylinder preparation activities would be greater if the cylinder transfer option were implemented than if the cylinder overcontainer option were implemented (see Section E.3.7). The cylinder transfer option would require construction and operation of both cylinder transfer and cylinder treatment facilities at each site. The waste management impacts from cylinder transfer facilities would be minimal, representing less than 7% of the various types of waste loads at any of the three sites.

The waste management impacts from operating a cylinder treatment facility capable of treating the entire cylinder inventory are presented in Section F.3.7.4. Construction of this cylinder treatment facility would generate about 18 m^3 of hazardous waste; its operation would generate about 48 m^3/yr of LLW, 0.2 m^3/yr of LLMW, and 2 m^3/yr of hazardous waste. These volumes would represent negligible impacts to the waste management system. However, they exclude the crushed cylinders, which would represent a volume of about 6,200 m^3/yr. It was assumed that treated crushed cylinders would become part of the DOE scrap metal inventory. If a decision to dispose of the crushed cylinders was made, the treated cylinders would be disposed of as LLW, representing a 3% addition to the projected DOE complexwide LLW disposal volume. Under the cylinder transfer option, an unknown number of empty cylinders requiring treatment would be generated. The number of empty cylinders would range from about 9,600 to 28,351 at the Paducah site, 2,600 to 13,388 at the Portsmouth site, and 2,342 to 4,683 at the K-25 site. The impacts from disposal of the empty crushed cylinders would be proportional to the percentage of the inventory requiring cylinder transfer.

The operation and construction of a consolidated long-term storage facility would generate LLW and LLMW. The generation of LLW would result from the repair or repackaging of failed cylinders. The long-term storage of UF_6 would generate a total of approximately 2,150 m^3 of LLW and 560 m^3 of LLMW for storage in yards, and about 60 m^3 of LLW for storage in either buildings or a mine. Compared with national and regional waste management capabilities (see Appendix C, Section C.10), the generation of waste under the long-term storage as UF_6 alternative would have a negligible to small impact.

5.2.8 Resource Requirements

Construction and operation of facilities under the long-term storage as UF_6 alternative would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that are generally irretrievable resources. The total quantities of commonly used materials are not expected to be significant and would not affect local, regional, or national availability of these materials. Very small amounts of strategic or critical materials are projected to be consumed during construction or operation of the facilities. In general, facility operational requirements are not resource intensive, and the resources required are not considered rare or unique. However, for storage in a mine, large quantities of electrical energy would be required during construction (about 840 MW-yr) because the majority of the construction equipment required to build the underground portion would be powered by electricity. The impact of this high electrical requirement on local energy resource use would be dependent on the location of the facility and the existing infrastructure. If a previously existing mine were used for storage, excavation and construction requirements would probably be reduced, depending on the characteristics and condition of the mine, and the electrical requirements would be subsequently reduced.

5.2.9 Land Use

The long-term storage as UF_6 alternative would result in negligible impacts to land use at the current cylinder storage sites. The maximum amount of additional land required for continued cylinder storage at any of the current storage sites would be less than 7 acres (2.8 ha), representing much less than 1% of the land available for development at the sites. Construction of a cylinder transfer facility at the current storage sites could require up to 21 acres (9 ha), but such an areal requirement would result in negligible land-use impacts at these sites.

Impacts on land use for consolidated long-term storage would depend on the location of the facility. The construction and operation of a long-term storage facility would require between 96 and 144 acres (38 to 58 ha), constituting a potentially moderate land use impact. For storage in a mine, on-site topographical modifications associated with the disposition of excavated material could potentially affect future on-site land use. Impacts to land use outside the boundaries of facilities would be negligible and limited to temporary traffic impacts associated with construction.

5.2.10 Cultural Resources

Impacts to cultural resources under the long-term storage as UF_6 alternative would be unlikely at the Paducah or Portsmouth sites. The existing and proposed storage yards at Paducah are located in previously disturbed areas unlikely to contain cultural properties or resources listed on or eligible for the *National Register of Historic Places*. No new storage yards are proposed at Portsmouth, so no cultural resources would be affected. A new storage yard is proposed at the K-25 site; although the exact location of the yard is unknown, it would probably be located in an area already dedicated to similar use. See Chapter 3 for a discussion of cultural resources existing at the three storage sites.

No impacts to cultural resources would be expected at the three current storage sites as a result of the cylinder overcontainer option because construction of a new facility would not be required. Impacts could result from the cylinder transfer option during construction of the transfer facilities. Specific impacts cannot be determined at this time and would depend on the future location of the facilities and whether listed or eligible cultural resources existed on or near that location. Operation of the transfer facility would not affect cultural resources. The impacts to cultural resources from the construction and operation of a consolidated long-term storage facility cannot be determined until the location of the facility is selected. However, impacts to cultural resources would be evaluated in Phase II studies and avoided if necessary and appropriate.

5.2.11 Environmental Justice

A review of the potential human health and safety impacts occurring for continued storage and cylinder preparation activities indicates that no disproportionately high and adverse effects to minority and low-income populations would be expected in the vicinity of the three current storage sites during normal operations. Although such populations reside within 50 miles (80 km) of the sites (see Appendix C), no disproportionate impacts would be expected. The results of accident analyses for continued cylinder storage and cylinder preparation activities also did not identify high and adverse impacts to the general public (i.e., the risk of accidents, consequence times probability, was less than 1). Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents would affect minority or low-income populations disproportionately.

5.3 LONG-TERM STORAGE AS URANIUM OXIDE

Under the long-term storage as uranium oxide alternative, depleted UF_6 was assumed to be chemically converted to an oxide at a conversion facility and the oxide placed in long-term storage. Conversion of depleted UF_6 to an oxide was assumed to take place at a newly constructed, stand-alone facility dedicated to the conversion process. Potential impacts were evaluated for conversion to and storage as both U_3O_8 and UO_2 (see Appendices F and G). For each, several long-term storage options were considered, including storage in buildings, belowground vaults, and an underground mine. To provide a conservative estimate of potential transportation and construction impacts, the conversion and long-term storage facilities were assumed to be located at sites other than the three current cylinder storage sites. Thus, transportation of cylinders from the three current storage sites to a conversion facility and transportation of uranium oxide from the conversion facility to a long-term storage facility were assumed.

The following is a summary of the activities analyzed under the long-term storage as uranium oxide alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage was assumed to continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped off-site to a conversion facility. The cylinder management activities that would occur at the sites were assumed to be similar to those under the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** Two cylinder preparation options for cylinders not meeting transportation requirements were considered: (1) a cylinder overcontainer option and (2) a cylinder transfer option (see Appendix E). The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three current storage sites.

- ***Conversion (Representative Site).*** Conversion was assumed to occur from 2009 through 2028 at a newly constructed, stand-alone conversion facility. Preoperations for conversion facilities were assumed to occur between 1999 and 2008 (with actual construction requiring 4 years).[1] As described in Appendix F, two representative conversion technologies were assessed for conversion to U_3O_8, and three for conversion to UO_2. The principal product of conversion would be either anhydrous HF, which would be shipped to a user facility, or CaF_2, which could be shipped for use or disposal.

- ***Transportation (Representative Routes).*** All UF_6 cylinders were assumed to be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to a conversion site. Following conversion, the U_3O_8 or UO_2 produced was assumed to be transported in drums by truck or rail to a long-term storage facility. In addition, HF and CaF_2 were assumed to require transportation to either a user or disposal facility.

- ***Long-Term Storage (Representative Site).*** Three options were considered for the storage of oxide, including storage in buildings, vaults, and a mine (see Appendix G). Drums of oxide were assumed to be received at the storage facility from 2009 through 2028. Construction of the facility would continue over a 20-year period while drums were being received. Following the

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[1] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

placement of the last container of oxide at the storage facility, monitoring and maintenance would occur from 2029 through 2039.

As described for the long-term storage as UF_6 alternative, cylinder management activities at the current storage sites for the long-term storage as oxide alternative were assumed to be similar to those that would occur under the no action alternative, including cylinder painting. As described for the long-term storage as UF_6 alternative, to provide a conservative estimate of impacts, no credit was taken for the effectiveness of cylinder yard improvements, cylinder maintenance, and painting in reducing cylinder corrosion rates. The number of hypothetical breached cylinders at the three current storage sites was estimated by assuming historical corrosion rates. Therefore, it was assumed that more cylinder breaches would occur under the long-term storage as oxide alternative than under the no action alternative, even though the cylinder storage time at the current storage sites would be shorter.

In terms of potential environmental impacts, the most important difference between the long-term storage as oxide alternative and the no action alternative is the requirement of a conversion facility. Conversion of UF_6 to uranium oxide would require process chemicals, most notably ammonia. Conversion could also produce large quantities of anhydrous HF. If accidentally released, both of these chemicals could cause serious adverse effects. Accidental releases of these chemicals could potentially occur at a conversion facility or during transportation. If the HF produced by conversion were neutralized to form CaF_2, shipments of anhydrous HF could be avoided. The potential environmental consequences of all activities under the storage as uranium oxide alternative, as outlined above, are provided in Sections 5.3.1 through 5.3.11.

The DOE plan for the management of the depleted UF_6 inventory that was in place during most of the preparation of this PEIS (described in Sewell 1992) is summarized in Section 1.1. The activities described under the former plan are very similar to those considered under the long-term storage as oxide alternative. The primary difference between the former plan and the long-term storage as oxide alternative is one of timing. Under the former plan, conversion of UF_6 to uranium oxide was anticipated to begin in 2020 and to continue for 20 years, through 2039. Under the long-term storage as oxide alternative, conversion is assumed to begin in 2009 and also to continue for 20 years, through 2028 (storage of the oxide was evaluated from 2029 through 2039). Therefore, under the former plan, cylinders would remain at the sites for about 10 years longer than is assumed under the long-term storage as oxide alternative. However, the environmental impacts for the long-term storage as oxide alternative are considered to be representative of those that would occur under the former management plan.

5.3.1 Human Health and Safety

During implementation of the long-term storage as oxide alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. The principal facilities involved include the current storage sites, a conversion facility, and a consolidated long-term storage facility. These impacts are discussed in Sections 5.3.1.1 and 5.3.1.2.

5.3.1.1 Normal Facility Operations

5.3.1.1.1 Workers

The total radiation exposure of involved workers under the long-term storage as oxide alternative would be greater than under the no action alternative because of the additional activities required for preparation of cylinders for shipment, conversion operations, and long-term storage operations. However, the exposures would still be well within all applicable health standards.

At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting, cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a conversion facility would be exposed to radiation while handling incoming cylinders, during conversion operations, and while handling uranium oxide. At a long-term storage facility, involved workers would be exposed to radiation during the placement of drums of uranium oxide into long-term storage. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

The estimated number of potential radiation-induced LCFs among involved workers from 1999 through 2039 is summarized in Figure 5.2. About 1 to 2 additional LCFs were estimated among the involved worker population, compared with 1 for the no action alternative. The impacts to involved workers would be similar for the storage of U_3O_8 and UO_2. In addition, the impacts would be essentially the same for storage in buildings, vaults, or a mine because all three options would involve handling the same amount of radioactive material and would require the same general types of activities. Radiological impacts to noninvolved workers were estimated to be negligible compared to those for involved workers (i.e., less than 1% of the involved worker impacts).

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations are not expected. The workplace would be monitored to ensure that airborne chemical concentrations are within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, workers would be provided with appropriate protective equipment, as necessary. The potential chemical exposure of noninvolved workers from any airborne releases during normal operations was estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, and a consolidated storage facility).

5.3.1.1.2 General Public

The potential impacts to members of the general public during normal operations would be similar to those under the no action alternative — all exposures were estimated to be within

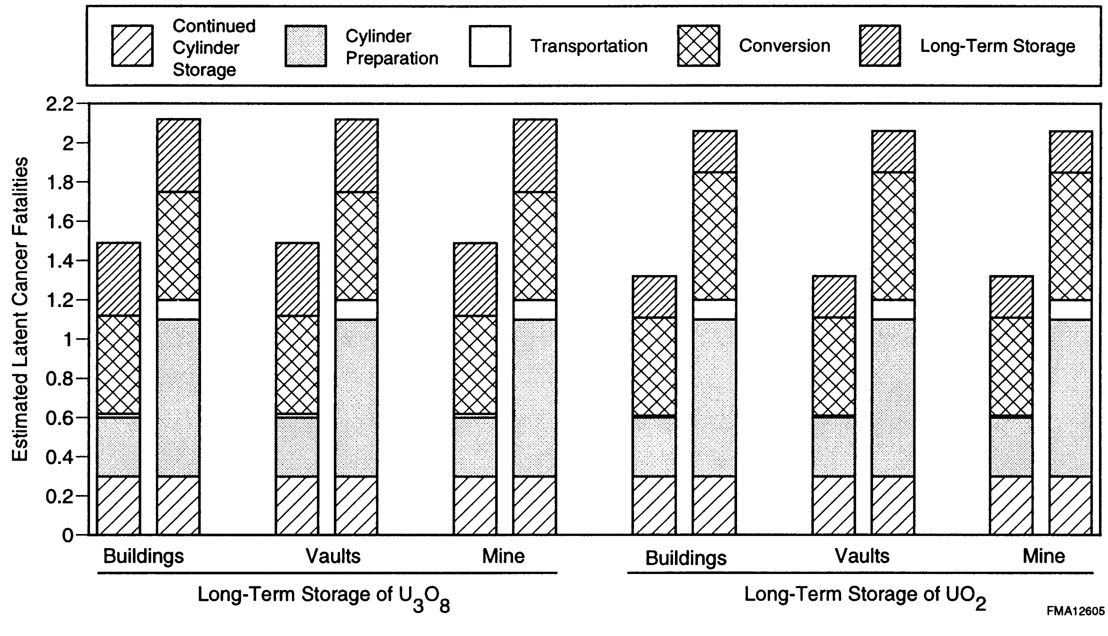

FIGURE 5.2 Total Estimated Number of LCFs among Involved Workers from Radiation Exposures during Normal Operations for the Long-Term Storage as Oxide Alternative, 1999 through 2039 (Note: The two bars presented for each option represent the minimum and maximum impacts estimated.)

applicable public health standards. No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites, near a conversion facility, or near a consolidated long-term storage facility from depleted UF_6 management activities.

At the current storage sites, potential public exposures to radiation and chemicals released from the sites would be exactly the same as described in Section 5.2.1.1.2 for the long-term storage as UF_6 alternative.

At a conversion facility, members of the general public could potentially be exposed to small amounts of uranium and HF released to the air during normal operations. The total collective radiation dose to the general public from airborne emissions was estimated to range from about 1.0 to 10 person-rem over the operational period of the conversion facility (2009 through 2028). This range takes into account the different conversion options and environmental settings considered (see Appendix F). This level of exposure was estimated to most likely result in zero LCFs among members of the general public. The maximum radiation dose to an individual near a conversion site was estimated to be less than about 0.03 mrem/yr from airborne emissions, well within applicable health standards (40 CFR Part 61; DOE Order 5400.5). If an individual were to receive the maximum estimated dose every year the conversion facility operated (2009 through 2028), the total dose would be about 1 mrem, with a resulting chance of dying from a radiation-induced latent cancer of less than 1 in 1 million. No noncancer health effects from exposure to airborne uranium and HF be expected — the hazard index for an individual near a conversion facility was estimated to be less than 0.0002.

At a consolidated long-term storage site, drums of uranium oxide would be stored within buildings, vaults, or a mine. The engineering analysis report indicates that emissions of uranium or chemicals from the storage facilities during normal operations would be negligible (LLNL 1997a). Drums would be routinely inspected and repaired, if necessary, and the storage facilities would include high-efficiency air filters. Therefore, no adverse health impacts to the general public in the vicinity of the storage site would be expected during normal operations.

5.3.1.2 Facility Accidents

5.3.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related fatalities and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be killed or injured during the long-term storage as oxide alternative as a result of accidents unrelated to any radiation or chemical exposures.

The accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries. The estimated number of worker fatalities and injuries would be greater than it would be under the no action alternative because of the additional construction and operational activities required for cylinder preparation, conversion, and consolidated long-term storage facilities. The number of fatalities and injuries would depend on the specific cylinder preparation, conversion, and long-term storage options. Considering all options, a range of 1 to 2 accidental worker fatalities was estimated over the 41-year period.

The number of estimated worker injuries (injuries resulting in lost workdays) is shown in Figure 5.3. Considering all storage facility options, the estimated total number of injuries would range from about 700 to 1,600 over the 41-year period. At the current storage sites, the maximum total number of injuries was estimated to be about 700, assuming that a cylinder transfer facility would be constructed and operated at each site. If cylinder overcontainers were used as the cylinder preparation option, a maximum of about 150 worker injuries was estimated at the three sites combined. Approximately 460 to 660 worker injuries were estimated to occur at a conversion facility (including treatment of empty cylinders), and approximately 100 to 200 worker injuries were estimated to occur at a long-term storage facility. The total number of injuries for storage as U_3O_8 or UO_2 would be similar. These rates would not be unique to the activities required for the alternative but would be typical of any industrial project of similar size and scope.

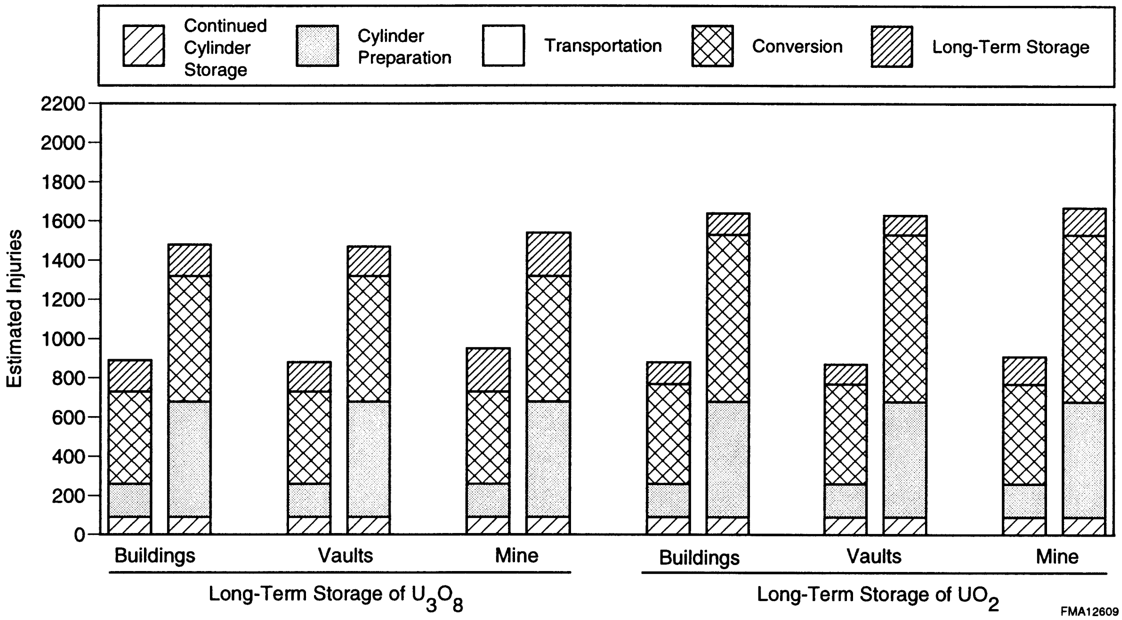

FIGURE 5.3 Total Estimated Number of On-the-Job Injuries (defined as injuries resulting in lost workdays) among All Workers from Construction and Operation of Facilities for the Long-Term Storage as Oxide Alternative, 1999 through 2039 (The two bars for each option represent the minimum and maximum impacts estimated.)

5.3.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the long-term storage as oxide alternative, accidents potentially releasing radiation and chemicals could occur at the three current storage sites (during continued cylinder storage through 2028), at a conversion site, and at a long-term storage site. At each site, a range of accidents was evaluated, from those considered reasonably likely to occur (once or more in 100 years on average) to those that would be extremely rare (expected to occur less than once in 1 million years on average). The accidents considered are described in Appendix D, Section D.2.2, for continued cylinder storage; Appendix F, Section F.3.2, for conversion; and Appendix G, Section G.3.2, for long-term storage. The consequences of accidents were estimated for both the noninvolved workers at the sites and the general public living around the sites. Fatalities and injuries to involved workers who are near the accident site when an accident occurs are possible from all accidents (see Section 4.3.2.1).

At the three current storage sites, the potential cylinder accidents that could result in a release would be the same as the accidents discussed for the no action alternative. The estimated consequences of cylinder accidents at the current storage sites are discussed in Section 5.1.1.2.2.

At a conversion site, potential accidents could result in releases of depleted UF_6 from cylinders (a small inventory of cylinders would be temporarily stored at the conversion site awaiting processing). In addition, accidents involving releases of chemicals, such as ammonia and HF, would be possible. Ammonia is required for conversion, and HF is produced as a conversion by-product. The potential consequences of conversion accidents are discussed below and in detail in Appendix F.

The estimated consequences of conversion facility accidents are summarized in Table 5.4 for chemical effects and in Table 5.5 for radiation effects. The impacts are presented separately for accidents considered likely (defined as accidents with an estimated frequency greater than once per 100 years) and for those rare, low-probability accidents estimated to result in the largest potential impacts. Although other accidents were evaluated, including those at a long-term storage site, the consequences of other accidents would be less than those summarized in the tables. The consequences presented are conservative because they are based on the assumption that the wind would be blowing in the direction of the greatest number of people at the time of the accident and that weather conditions would limit dispersion in the air, resulting in high concentrations. In addition, the effects of protective measures, such as evacuation, were not considered. The actual consequences of accidents would be expected to be less than those discussed.

Chemical Effects. The potential consequences from chemical exposures of all conversion accidents considered likely to occur (i.e., a frequency greater than once per 100 years) would be zero adverse effects among members of the general public (Table 5.4); the off-site concentrations of chemicals released and transported downwind were estimated to be below levels causing adverse chemical health effects.

Noninvolved workers at a conversion site could be affected by chemical releases from accidents considered likely. The likely accident estimated to result in the greatest total number of adverse chemical effects among noninvolved workers is the failure of a corroded cylinder, spilling part of its contents under dry weather conditions. Such an accident could occur, for example, during handling of the cylinders. An estimated 24 lb (11 kg) of UF_6 could be released in such an accident. If this accident occurred at a conversion facility, it was estimated that up to 240 noninvolved workers might suffer potential adverse effects from exposure to HF and uranium (mostly mild and transient effects, such as respiratory irritation or temporary decrease in kidney function). The number of affected noninvolved workers for the same accident is greater at the conversion facility than at the current storage sites (Table 5.1) because of the number and closer proximity of the workers at the conversion facility. A different accident was estimated to result in the greatest potential number of irreversible adverse effects among noninvolved workers. The likely conversion accident estimated to result in the greatest total number of irreversible adverse effects would be an accident involving the release of ammonia vapor from a stripping column. If such an accident occurred, up to 40 noninvolved workers might experience irreversible adverse effects (such as organ damage). Exposure to ammonia is expected to cause death in about 2% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Therefore, 1 noninvolved worker fatality was estimated if the accident occurred (2% of 40).

TABLE 5.4 Estimated Consequences of Chemical Exposures for Accidents under the Long-Term Storage as Oxide Alternative[a]

Receptor[b]	Accident Scenario	Activity	Accident Frequency Category[c]	Effect[d]	Consequence[e] (persons affected)
			Likely Accident(s)		
General public	All accidents	Conversion	L	Adverse effects	0
	All accidents	Conversion	L	Irreversible adverse effects	0
	All accidents	Conversion	L	Potential fatalities	0
Noninvolved workers	Corroded cylinder spill, dry conditions	Conversion	L	Adverse effects	240
	Ammonia stripper overpressure	Conversion	L	Irreversible adverse effects	40
	Ammonia stripper overpressure	Conversion	L	Potential fatalities	1
			Low Frequency-High Consequence Accident(s)		
General public	HF tank rupture	Conversion	I	Adverse effects	41,000
	Ammonia tank rupture	Conversion	I	Irreversible adverse effects	1,700
	Ammonia tank rupture	Conversion	I	Potential fatalities	30
Noninvolved workers	HF tank rupture	Conversion	I	Adverse effects	1,100
	Corroded cylinder spill, wet conditions – water pool	Conversion	EU	Irreversible adverse effects	440
	Corroded cylinder spill, wet conditions – water pool	Conversion	EU	Potential fatalities	4

[a] The accidents listed are those estimated to result in the greatest impacts among all the accidents considered. The impacts for a range of accidents at a conversion facility are listed in Appendix F.

[b] Noninvolved workers are persons working at the site but not involved in hands-on depleted UF_6 management activities. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/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] Potential adverse effects include exposures that could result in mild and transient injury, such as respiratory irritation. Potential irreversible adverse effects include exposures that could result in permanent injury (e.g., impaired organ function) or death. The majority of the adverse effects would be mild and temporary in nature. For HF exposures, it is estimated that less than 1% of the predicted potential irreversible adverse effects would result in fatalities. For exposures to ammonia, it is estimated that about 2% of the predicted irreversible adverse effects would result in fatalities.

[e] The consequence is expressed as the maximum number of individuals with the predicted exposure level sufficient to cause the corresponding health endpoint. The estimated consequences were based on the assumption that the meteorological conditions would be F stability with 1 m/s wind speed, considered to be the worst conditions, and that the wind would be blowing in the direction of the highest worker or public population density.

TABLE 5.5 Estimated Consequences from Radiation Exposures for Accidents under the Long-Term Storage as Oxide Alternative[a]

				MEI		Population	
Receptor[b]	Accident Scenario	Activity	Accident Frequency Category[c]	Dose (rem)	Lifetime Risk of LCF	Dose (person-rem)	Number of LCFs
			Likely Accident(s)				
General public	Corroded cylinder spill, dry conditions	Conversion	L	0.0023	1×10^{-6}	0.3	0.0002
Noninvolved workers	Corroded cylinder spill, dry conditions	Conversion	L	0.077	3×10^{-5}	7.1	0.003
			Low Frequency-High Consequence Accident(s)				
General public	Earthquake	Conversion	EU	0.27	0.0001	20	0.01
Noninvolved workers	Earthquake	Conversion	EU	9.2	0.004	840	0.3

[a] The accidents listed are those estimated to have the greatest impacts among all accidents considered. The impacts for a range of accidents at a conversion facility are listed in Appendix F. The estimated consequences were based on the assumption that the wind would be blowing in the direction of the highest worker or public population density and that weather conditions would limit dispersion.

[b] Noninvolved workers are persons working at the site but not involved in hands-on depleted UF_6 management activities. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

[c] Accident frequencies: likely (L), estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/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).

The engineering analysis report (LLNL 1997a) gave the frequency of likely accidents as greater than once in every hundred years; for assessment purposes, the specific frequency of likely accidents was assumed to be about once in 10 years (0.1 per year). Therefore, over a 20-year operational period, about 2 such accidents would be expected. Over the operational period of the conversion facility, the maximum accident risk (defined as consequence times probability) of likely accidents would be about 480 noninvolved workers with potential adverse effects and 80 noninvolved workers with potential irreversible adverse effects. The risk of fatalities would be about 2% of the 80 irreversible adverse effects, or about 2 fatalities. The number of noninvolved workers actually experiencing these effects would probably be considerably smaller, depending on the actual circumstances of the accident and the individual chemical sensitivity of the workers.

Conversion accidents that are less likely to occur could have much greater consequences. These rare accidents (low probability of occurrence) could cause adverse effects among both workers and members of the general public living around a conversion facility.

The conversion accident estimated to result in the greatest potential number of adverse chemical effects to members of the general public would be an accident involving rupture of an HF tank. In this accident, a tank was assumed to be ruptured by an earthquake or other major event, releasing about 8,000 lb (3,600 kg) of anhydrous HF. The occurrence of such an accident is considered incredible, expected to occur less than once in 1 million years. If this accident did occur, it was estimated that up to 41,000 members of the general public might experience adverse effects from HF exposure, mostly mild and transient effects such as respiratory irritation. A different accident, also considered incredible, was estimated to result in the greatest number of potential irreversible adverse effects among the general public. An ammonia tank rupture, caused by an earthquake, was assumed to release about 120,000 lb (55,000 kg) of ammonia. If such an accident were to occur, it was estimated that up to 1,700 members of the general public could experience irreversible adverse effects such as organ damage (the HF tank rupture accident would cause fewer than 1,700 irreversible effects). Exposure to ammonia would be expected to cause death in about 2% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Therefore, about 30 fatalities could occur (2% of 1,700).

Rupture of an HF tank would also cause the greatest potential number of adverse effects among noninvolved workers. An HF tank rupture could cause up to 1,100 noninvolved workers to experience adverse effects, mostly mild and transient effects such as respiratory irritation. However, a corroded cylinder spill accident (under wet conditions) was estimated to result in the greatest potential number of irreversible adverse effects among conversion facility workers. This accident is considered extremely unlikely, expected to occur between once in 10,000 years and once in 1 million years. If this accident occurred, it was estimated that up to 440 noninvolved workers might experience irreversible adverse effects (such as lung damage) from exposure to HF and uranium. For HF exposure, the number of fatalities would be expected to be less than 1% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Thus, about 4 fatalities among noninvolved workers could occur (1% of 440).

Although these accidents could have serious consequences to workers and members of the general public, they would not be expected to occur during the lifetime of the conversion facility. The most likely number of people (both workers and the general public) who would suffer from an irreversible adverse health effect or fatality as a result of one of these accidents is estimated to be zero (calculated by be multiplying the consequence times the probability of these accidents).

Radiation Effects. Potential conversion accidents could release uranium, which is radioactive in addition to being chemically toxic. Uranium could be released as UF_6 from cylinders or as uranium oxide. For conversion accidents, the potential impacts from radiation exposures were estimated to be much less than the impacts from chemical exposures. The radiation impacts from potential conversion accidents are given in Table 5.5. For all conversion accidents considered, the radiation doses from released uranium were estimated to be considerably below levels likely to cause radiation-induced effects among noninvolved workers and members of the general public and below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents.

The accident considered likely (i.e., a frequency greater than once in 100 years) that would have the largest consequences from radiation exposures would be a corroded cylinder spill accident (dry conditions). If this accident occurred, the radiation dose to a maximally exposed member of the general public was estimated to be less than 3 mrem, resulting in an increased risk of death from cancer of about 1 in 1 million. The total population dose to the general public within 50 miles (80 km) was estimated to be less than 1 person-rem, estimated to most likely result in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be 77 mrem, resulting in an increased risk of death from cancer of about 1 in 30,000. The total dose to all noninvolved workers was estimated to be about 7.1 person-rem. This dose to workers was estimated to most likely result in zero LCFs.

The potential conversion accident estimated to result in the largest estimated radiation doses would be an earthquake releasing uranium from an oxide storage building. This accident is considered extremely unlikely, expected to occur between once in 10,000 years and once in 1 million years. If this accident occurred, the radiation dose to a maximally exposed member of the general public was estimated to be about 270 mrem, resulting in an increased risk of death from cancer of about 1 in 10,000. The total population dose to the general public within 50 miles (80 km) was estimated to be 20 person-rem, most likely resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be about 9 rem (9,000 mrem), resulting in an increased risk of death from cancer of about 4 in 1,000. The total dose to all noninvolved workers was estimated to be about 840 person-rem. This dose to workers was estimated to most likely result in zero LCFs.

5.3.2 Transportation

Long-term storage as oxide could potentially require the shipment of both radioactive material and chemicals. The major materials assumed to be transported are summarized in Table 5.6. Potential materials transported include depleted UF_6 cylinders, uranium oxide, chemicals required for conversion, and products of conversion. In addition, some shipments of LLW and LLMW produced during processing would be required. The assessment of potential transportation impacts considered both truck and rail shipment options and evaluated impacts from both normal (incident-free) transportation operations and accidents. Because the locations of conversion and long-term storage sites will be evaluated in Phase II studies and NEPA reviews, for purposes of comparison, it was assumed that all shipments would travel a distance of 620 miles (1,000 km), primarily through rural areas but including some suburban and urban areas. The transportation assumptions and estimated impacts for a range of shipment distances are discussed in detail in Appendix J.

TABLE 5.6 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Long-Term Storage as Oxide Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Conversion site	46,422	11,600[d]	2	1
Uranium oxide (U_3O_8 or UO_2)	Conversion site	Long-term storage site	25,500 – 26,800	8,480 – 8,960	1	1
Ammonia	Supplier	Conversion site	520 (U_3O_8 conversion)	960 – 1,120 (UO_2 conversion)	0	0
Anhydrous HF (if produced)	Conversion site	User	–	4,860	0	0
CaF_2 (if HF neutralized)	Conversion site	User or disposal site	19,800	7,300	1	0
LLW/LLMW	Current storage/ conversion sites	Treatment/disposal site	900 - 2,360	–	0	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Collocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments when either the truck or rail mode is assumed to be used.

[c] Number of estimated traffic accident fatalities when each shipment is assumed to travel 620 miles (1,000 km) and national average accident statistics are used. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

The transportation assessment was intended to provide a conservative estimate of the potential impacts that could occur. Therefore, it was assumed that all depleted UF_6 cylinders (46,422) would be transported from the three current storage sites to an independent conversion facility. Approximately 11,600 railcar shipments (four cylinders per railcar) or 46,422 truck shipments (one cylinder per truck) would be required. Furthermore, following conversion, the uranium oxide (either U_3O_8 or UO_2) was assumed to be packaged into drums and transported to a long-term storage facility. If all the UF_6 were converted, shipment of the oxide produced would require about 26,000 truck shipments or 9,000 railcar shipments. Collocating conversion and long-term storage facilities would minimize the potential amount of transportation required.

Conversion to oxide might require and might produce chemicals that could have adverse health impacts if accidentally released, primarily ammonia and anhydrous HF. Both ammonia and HF are potentially toxic chemicals commonly transported as liquids in trucks and rail tank cars. Depending on the conversion process, about 500 truck shipments of ammonia to a U_3O_8 conversion facility and up to about 1,100 rail shipments of ammonia to a UO_2 conversion facility would be required over the 20-year operational period. Anhydrous HF could be produced as a by-product of conversion and could be transported to a user. Up to about 5,000 railcars of anhydrous HF would be produced if all the UF_6 were converted to oxide. Alternatively, the HF could be neutralized to CaF_2, a nontoxic solid, at the conversion site. The CaF_2 could also be transported to a user or shipped for disposal.

5.3.2.1 Normal Transportation (Incident-Free) Operations

During normal transportation operations, radioactive material and chemicals would be contained in their transport packages. Potential health impacts would be possible from exposure to low-level external radiation in the vicinity of shipments of cylinders and uranium oxide. In addition, exposure to vehicle engine exhaust emissions could cause adverse effects.

The total impacts during normal operations were estimated by assuming that all the cylinders, uranium oxide, process chemicals, and by-products required or produced would be shipped 620 miles (1,000 km). During normal operations, a total of 0 fatalities was estimated among workers and members of the general public, combined, if rail shipments were used, and 1 fatality was estimated if truck shipments were used. Rail transport results in smaller overall impacts because fewer shipments would be required. There would be no difference in impacts from the transportation of U_3O_8 or UO_2. Members of the general public living along truck and rail transportation routes were estimated to receive less than 0.1 mrem, even if a single person were to be exposed to every shipment of radioactive material during the program.

5.3.2.2 Transportation Accidents

Transportation accidents could occur during the transportation of radioactive materials and chemicals. These accidents could potentially affect the health of workers (i.e., crew members) and members of the general public. Potential impacts were estimated for two types of accidents: (1) typical traffic accidents that could cause deaths from physical trauma, unrelated to the cargo being shipped, and (2) accidents that could involve the release of radioactive material or chemicals from a shipment.

5.3.2.2.1 Traffic Accidents with No Release

All shipments could be involved in truck or rail traffic accidents, with a chance that fatalities could result. Historical traffic accident statistics were used to predict the number of traffic fatalities that might result from future shipments. The expected number of traffic fatalities depends on the total number of shipments, the shipment distance, the shipment mode (truck or rail), and the historical accident fatality rates.

The total numbers of traffic fatalities were estimated by assuming that all the cylinders, uranium oxide, process chemicals, and by-products required or produced would be shipped 620 miles (1,000 km) by either truck or rail (see Table 5.6). If truck shipments were used, an estimated 4 traffic fatalities could result; if rail shipments were used, an estimated 2 traffic fatalities could result. Rail transport would result in a lower number of estimated traffic fatalities, primarily because railcars have a larger shipment capacity than trucks, resulting in fewer shipments. The actual number of fatalities would be much less if the number of shipments and shipment distances were reduced.

5.3.2.2.2 Traffic Accidents Involving Releases of Radiation or Chemicals

In most accidents, the radioactive material or chemicals being shipped would remain in the transport packages. However, in severe accidents, there is a potential for serious consequences if releases of anhydrous HF, ammonia, and depleted UF_6 (from cylinders) were to occur. If accidentally released, anhydrous HF and ammonia were estimated to have the greatest potential consequences of the materials that might require transportation. The consequences and risks of transportation accidents involving UF_6 cylinders are discussed in Section 5.2.2.2. Severe accidents involving the shipment of uranium oxide could also result in adverse effects from exposure to radiation, although the effects would be considerably less adverse than the consequences of UF_6 cylinder accidents (see Appendix J).

During the shipment of HF or ammonia, a severe accident could cause a release to the air from a truck or railcar. The amount released would depend on the severity and conditions of the accident. The material released could be dispersed downwind, potentially exposing members of the general public to chemical effects. The consequences would depend on the material released, the amount released, the location of the accident, and the weather conditions at the time. Potential consequences would be greatest in urban areas because more people could be exposed. Accidents that occurred when the weather was very stable (typical of nighttime conditions) would have higher potential consequences than accidents that occurred when the weather was unstable (i.e., turbulent, typical of daytime conditions). The consequences would be greater under stable conditions because the stability of the weather would determine how quickly the released material was dispersed and diluted to lower concentrations as it moved downwind.

The accident estimated to have the highest potential consequences would be a severe rail accident involving a release from a railcar containing anhydrous HF. The consequences of such an accident were estimated on the basis of the assumption that the accident occurred in an urban area under stable weather conditions (such as at nighttime). The probability of such an accident would depend on the total number of shipments, the distance between the origin and destination sites, and the characteristics of the route. For conversion of the entire UF_6 inventory to oxide, the amount of anhydrous HF produced could be enough to fill about 5,000 railcars. On the basis of assuming that each shipment would travel 620 miles (1,000 km) and using the national average accident statistics for railcars and representative route characteristics, the probability of an accidental HF release in an urban area would be about 1 in 30,000 (3×10^{-4}). If the HF were neutralized to CaF_2, no shipments of HF would be required.

If a large HF release from a railcar occurred in an urban area under stable weather conditions, persons within a 7 mi^2 (18 km^2) area downwind of the accident site (including crew members) could potentially suffer irreversible adverse effects from chemical exposure to HF. In a densely populated urban area, it was estimated that up to 30,000 persons might experience irreversible adverse effects such as lung damage. The number of fatalities following HF exposure would be expected to be somewhat less than 1% of the number of potential irreversible adverse effects (Policastro et al. 1997). Thus, up to 300 fatalities could occur (1% of 30,000). If the same type of HF rail accident were to occur in a typical rural area, which would have a smaller population density than an urban area, potential impacts would be considerably less. In a rural area, it was estimated that approximately 100 persons might experience irreversible adverse effects, resulting in about 1 fatality.

The weather conditions at the time of an accident would also significantly affect the expected consequences of a severe HF accident. The consequences of an HF rail accident would be much smaller under unstable weather conditions, the most likely conditions in the daytime. Unstable weather conditions would result in more rapid dispersion of the airborne HF plume and in lower downwind concentrations. Under unstable conditions, a downwind area of about 1 mi^2 (2 km^2) could be affected by a railcar accident. In such a case, approximately 3,000 persons were estimated to potentially experience irreversible adverse effects, including about 30 fatalities, if the accident occurred in an urban area. If the accident occurred in a rural area during unstable weather conditions, 10 persons were estimated to potentially experience irreversible adverse effects, with less than 1 fatality.

The estimated probability of occurrence of this accident in an urban area is about 0.00003. Therefore, at most, one individual would be estimated to experience an irreversible adverse effect because of this accident over the 20-year shipping period (calculated by multiplying the probability [0.00003] times the consequence [30,000] for an urban area under stable weather conditions). The number of fatalities estimated over the same period would be zero (1% of 1).

Another way to interpret the risk posed by an HF accident is to examine the risk of potential irreversible adverse effects to a specific individual who lived along a transportation route. Following a severe accident under stable weather conditions (which would result in the highest concentrations and consequences), HF air concentrations high enough to cause potential irreversible adverse effects could extend as far as 12 miles (20 km) downwind in a narrow band covering approximately 7 mi^2 (18 km^2). Therefore, an individual living near a route could be affected by an accident that occurred up to approximately 12 miles (20 km) in either direction (although the wind would have to be blowing in the direction of the individual). If all 5,000 HF shipments were along the same route, the probability of a severe HF accident occurring within 12 miles (20 km) in either direction of an individual near the route would be about 0.0005 (1 chance in 2,000) based on national statistics for severe accidents. However, the risk of the individual suffering potential irreversible adverse effects as a result of the accident would actually be less than 1 chance in 2,000 because the estimate was based on the assumption that the wind was blowing in the direction of the individual under stable weather conditions (the wind could be blowing in any direction and stable conditions occur, on average, about one-sixth of the time in the United States).

The consequences discussed for anhydrous HF accidents are meant to provide a conservative estimate of potential impacts. To provide perspective, anhydrous HF is routinely shipped commercially in the United States for industrial applications. Since 1971, the period covered by DOT records (Process Safety Engineering, Inc. 1994), there have been no fatal or serious injuries to members of the general public or to transportation or emergency response personnel as a result of anhydrous HF releases during transportation. Over that period, 11 releases from railcars (only one since 1985) have been reported. The amounts of HF released in these incidents were less than 1% of the shipment contents, except in one case. The only major release occurred in 1985 and resulted in approximately 100 minor injuries. The last HF release during transportation was a minor release in 1990. The improved safety record of transporting anhydrous HF in the past 10 years may be attributed to such practices as installing protective devices on railcars, an overall decline in the number of derailments, closer manufacturer supervision of container inspections, and participation of shippers in the Chemical Transportation Emergency Center (CHEMTREC).

Accidents involving ammonia could also result in severe consequences, but much less severe than those for the anhydrous HF accidents discussed above. Some conversion options could require up to about 1,000 railcar shipments over the duration of the program. On the basis of conservative assumptions, a severe railcar accident releasing ammonia in an urban area under stable weather conditions could result in up to 5,000 persons experiencing potential irreversible adverse effects. In a rural area, it was estimated that about 20 persons could experience potential irreversible adverse effects. However, because fewer shipments of ammonia than of anhydrous HF would be required, the risk associated with ammonia shipments would be less than the risk posed by anhydrous HF shipments. Exposure to ammonia would be expected to cause death in about 2% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Therefore, up to 100 fatalities could occur (2% of 5,000) for an urban accident and less than 1 fatality for a rural accident (2% of 20). As discussed for anhydrous HF accidents, when the probability of occurrence of ammonia accidents is considered, the number of fatalities that could occur over the 20-year shipping campaign because of a severe ammonia accident was estimated to be zero. Ammonia is also commonly shipped in the United States for industrial applications.

Although accidents involving shipments of LLW and LLMW could occur, the consequences of the most severe accidents involving these materials would not be expected to cause any LCFs from radiation exposures or any irreversible adverse effects from exposure to chemicals.

5.3.3 Air Quality

The analysis of potential impacts on air quality for the long-term storage as oxide alternative considered the potential for air pollutant emissions from continued cylinder storage activities occurring through 2028, cylinder preparation activities, conversion, and long-term storage activities. For continued cylinder storage and cylinder preparation activities at the current sites, impacts would be identical to those discussed for the long-term storage as UF_6 alternative (Section 5.2.3).

At a conversion facility, air quality impacts would depend on the actual facility location; however, concentrations of criteria pollutants for the representative settings were all estimated to be within standards. Concentrations of PM_{10} during construction were estimated to be as high as 90% of the corresponding standard; procedures to reduce these emissions might have to be implemented during actual construction activities. Concentrations of the other criteria pollutants and HF were estimated to be less than 30% of respective standards during construction and less than 5% of respective standards during operations. An oxide conversion facility would emit between about 2 to 11 lb/yr (0.9 to 5 kg/yr) of uranium as either U_3O_8 or UO_2. No air quality standards exist for uranium compounds; however, potential health impacts of these emissions were evaluated in Section 5.3.1.1.

Concentrations of criteria pollutants and HF from a facility for long-term storage as oxide were estimated to be less than 12% of respective standards for all options.

5.3.4 Water and Soil

Water use during continued cylinder storage and cylinder preparation activities at the three current storage sites would be the same as that discussed in Section 5.2.4. At an oxide conversion facility, water use during construction would be between 4 and 12 million gal/yr; maximum water use during operations would be between 34 and 285 million gal/yr. Wastewater generation would range from about 15 to 140 million gal/yr.

For long-term storage in buildings, vaults, or a mine, water use during construction would be between 0.3 and 1.3 million gal/yr; maximum water use during operations would be about 1.4 million gal/yr. Wastewater generation would range from about 0.1 to 1.4 million gal/yr for all storage options. Impacts to surface water, groundwater, and soil are discussed in Sections 5.3.4.1 through 5.3.4.3.

5.3.4.1 Surface Water

Under the long-term storage as oxide alternative, potential impacts on surface water at the current storage sites during continued storage of the cylinders and cylinder preparation would be the same as those discussed for storage as UF_6 (Section 5.2.4.1). At an oxide conversion facility, impacts to surface water would depend on the actual location of the facility. However, an assessment of the representative settings considered in the PEIS indicates that impacts to runoff and floodplain encroachment would be negligible. Concentrations of uranium in effluents from a conversion facility would range from about 25 to 400 µg/L. After dilution in nearby surface water, concentrations probably would be much less than the 20 µg/L used as a guideline. Operation of any conversion facility would be contingent on meeting all applicable regulations and site-specific permit requirements.

Although dependent on the actual site location, impacts to runoff and floodplain encroachment during storage as oxide would probably be negligible. An assessment of the representative settings considered in the PEIS indicates that concentrations of uranium released in wastewater would be very low and would result in concentrations much lower than 20 µg/L in the surface waters to which wastewaters would be released.

5.3.4.2 Groundwater

Potential impacts on groundwater quality for continued cylinder storage through 2028 at the current storage sites are discussed in detail in Section 5.2.4.2. Conservative calculations indicated that uranium concentrations in groundwater directly below the sites could reach maximums of 20, 4, and 9 µg/L for the Paducah, Portsmouth, and K-25 sites, respectively. Groundwater directly beneath the surface contamination source would be unlikely to be used as a drinking water source; estimated maximum concentrations at 1,000 ft (305 m) downgradient were 16, 3, and 8 µg/L for the Paducah, Portsmouth, and K-25 sites, respectively. Potential groundwater impacts would be mitigated by collecting and treating runoff from the cylinder yards and by identifying and repairing breached cylinders as soon as possible. Impacts to groundwater from cylinder preparation would be none to negligible because no releases to groundwater would be expected during operations.

At an oxide conversion facility, the impacts to groundwater would depend on the actual location of the facility. However, an assessment of the representative settings considered in the PEIS indicates that impacts on recharge, depth to groundwater, or direction of flow would be negligible (the maximum increase over current groundwater use was estimated to be 5%). Because discharges to groundwater are not planned (facility effluents would be released to nearby surface waters), there would be no direct impacts to groundwater quality.

For storage as oxide, the potential impacts to groundwater would also depend on the actual location. Potential impacts during construction would include groundwater contamination with construction chemicals. By adopting good engineering practices (e.g., covering material to prevent interaction with rain and promptly cleaning any chemical spills), the potential for adverse impacts to groundwater would be minimized. During operations, impacts to groundwater would be negligible because the building, vault, or mine would isolate contaminants released during normal operations.

5.3.4.3 Soil

Potential impacts on soil from continued cylinder storage through 2028 and from cylinder preparation activities at the current storage sites would be the same as those discussed in Section 5.2.4.3. Impacts on soil at conversion and long-term storage facilities would depend on the facility location. Potential impacts, which would tend to be temporary, would generally result from material excavated during construction that would be left on-site. The largest potential impacts on soil would occur for long-term storage in a mine. Construction of a mine for storage could require excavating between about 1.2 and 2.2 million yd^3 (930,100 to 1.7 million m^3) of consolidated material. In the short term, this amount of material would cause changes in site topography. In the long term, contouring and reseeding would return soil conditions back to their former state, and the impacts would be minor. If a previously existing mine were used for storage, excavation requirements could be significantly reduced, and potential impacts on soil would be much smaller. Potential impacts on soil from a conversion facility or from storage in buildings or vaults would be minor and temporary, much smaller than from storage in a mine.

5.3.5 Socioeconomics

Potential socioeconomic impacts at the current storage sites from continued cylinder storage through 2028 and cylinder preparation activities are discussed in Section 5.2.5. No significant impacts to ROI employment and population growth rates, vacant housing, or public finances would be expected.

The potential socioeconomic impacts of construction and operation of an oxide conversion facility (including impacts from cylinder treatment) would depend on the facility location. Construction activities would create short-term employment (340 to 730 direct jobs and 560 to 1,600 total jobs in the peak construction year); operational activities would create from 330 to

490 direct jobs and from 700 to 1,500 total jobs per year. Direct and total income from construction in the peak year would be from $16 to $33 million and from $19 to $48 million, respectively. During operations, direct and total income would be between $20 and $28 million/yr and from $27 to $42 million/yr, respectively. For the representative settings used for analysis, the employment and income created would represent a change of less than 0.1% of projected growth in these indicators of overall regional activity. The in-migration expected into the region containing an oxide conversion facility would have only a small impact on regional population growth rates. A moderate impact to housing could occur, with about 30% of the projected number of vacant rental housing units in the representative ROIs being required. Small impacts on local public finances would be expected, with all increases over forecasted baseline revenues and expenditures being less than 1%.

The potential socioeconomic impacts of construction and operation of a long-term storage facility would depend on facility location, oxide form (U_3O_8 or UO_2), and whether buildings, vaults, or a mine was selected. Construction activities would create employment (120 to 410 direct jobs in the peak construction year); operational activities would create from 60 to 70 direct jobs per year. Direct income from construction in the peak year would range from $5 to $20 million. During operations, direct income would range from $3 to $4 million/yr. For long-term storage, construction and operations would be occurring concurrently over the 20-year emplacement period.

For the representative settings used for analysis of building and vault options, the employment and income created would represent a change of less than 0.02% of projected growth in these indicators of overall regional activity (see Appendix G, Section G.3.5). The in-migration expected into the region containing an oxide storage facility would have only a small impact on regional population growth rates. Negligible impacts on local public finances would be expected. The impacts for mine storage were calculated for a generic site; therefore, no estimates of indirect impacts on employment and income were made for mine options.

5.3.6 Ecology

Potential ecological impacts of continued storage and cylinder preparation at the current storage sites would be the same as those discussed in Section 5.2.6. For conversion and long-term storage facilities, construction would disturb about 30 to 40 acres (12 to 16 ha) for conversion, 120 to 210 acres (49 to 85 ha) for long-term storage as U_3O_8, and 75 to 110 acres (30 to 45 ha) for long-term storage as UO_2. Existing vegetation at the conversion and long-term storage sites would be destroyed during land-clearing activities. In addition, wildlife would be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the locations of the facilities; however, some permanent loss of habitat could result. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility locations. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Impacts to ecological resources from facility operations at a conversion or long-term storage site would be negligible to small. The concentrations of radioactive and chemical contaminants in air and water emissions would be considerably below levels considered harmful to vegetation and wildlife.

Facility and transportation accidents (see Sections 5.3.1 and 5.3.2) 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 accident, season, and meteorological conditions.

5.3.7 Waste Management

The impacts on waste management operations from continued storage and cylinder preparation activities at the current sites through 2028 would be the same as those discussed in Section 5.2.7. The operation and construction of a conversion facility would also generate radioactive, hazardous, and sanitary solid wastes. Construction of U_3O_8 and UO_2 conversion facilities would generate a maximum of approximately 115 and 200 m^3, respectively, of hazardous waste. Conversion to U_3O_8 would generate about 140 to 600 m^3/yr of LLW, 1 m^3/yr of LLMW, and 7 m^3/yr of hazardous waste during operations. Conversion to UO_2 would generate about 170 to 740 m^3/yr of LLW, 0 to 18 m^3/yr of LLMW, and 7 to 17 m^3/yr of hazardous waste during operations (ranges are the result of assessing different conversion technologies).

During conversion, nonhazardous solid waste and wastewater generation rates could exceed the current rates at the representative settings considered in the analysis, but the actual facilities would be designed to meet appropriate waste treatment demands. Under the various oxide conversion options, CaF_2 could be produced. It is currently unknown whether this CaF_2 would be sold; whether its low uranium content would allow it to be disposed of as nonradioactive, nonhazardous solid waste; or whether it would have to be disposed of as LLW. The projected low level of uranium contamination (i.e., less than 1 ppm) suggests that sale or disposal as nonradioactive, nonhazardous solid waste would be most likely. If disposed of as nonradioactive, nonhazardous solid waste, approximately 380 to 11,000 m^3/yr would be generated, which would be 18 to 500% of current nonradioactive, nonhazardous solid waste loads at the representative settings; such an increased input could be managed by expanding the capacity for sanitary waste disposal at an actual conversion facility. If CaF_2 were considered to be LLW, it would probably have to be stabilized through grouting prior to disposal, increasing the volume to 21,300 m^3/yr for 20 years. This volume of LLW (up to 426,000 m^3 total) would represent about 10% of the projected DOE complexwide LLW disposal volume for approximately the same time period (i.e, 4.25 million m^3; see Appendix C, Section C.10). Disposal of CaF_2 as LLW could result in moderate impacts for waste management, if the LLW were considered to be DOE waste. Overall, the waste input resulting from normal operations at a conversion facility might have a moderate impact on waste management operations.

Conversion would also require construction and operation of a cylinder treatment facility. Construction of a cylinder treatment facility would generate about 18 m^3 of hazardous waste.

Operation of the treatment facility would generate about 48 m^3/yr of LLW, 0.2 m^3/yr of LLMW, and 2 m^3/yr of hazardous waste; these volumes represent negligible impacts to the waste management system. These volumes exclude the crushed cylinders, which would represent a volume of about 6,200 m^3/yr. It was assumed that the treated crushed cylinders would become part of the DOE scrap metal inventory. If a decision for disposing of the crushed cylinders was made, the treated cylinders would be disposed of as LLW, representing a 3% addition to the projected DOE complexwide LLW disposal volume.

The operation and construction of a long-term oxide storage facility would also generate radioactive LLW and nonradioactive, nonhazardous solid wastes. The generation of LLW would result from the repair or repackaging of failed storage containers (i.e., drums). The long-term storage as oxide alternative would generate a maximum of approximately 20 m^3 of LLW for storage in buildings, vaults, or a mine.

Compared with national and regional waste management capabilities (see Appendix C), the generation of waste under the long-term storage as oxide alternative would have a negligible to moderate impact.

5.3.8 Resource Requirements

Construction and operation of conversion and long-term storage facilities would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that are generally irretrievable resources. The total quantity of commonly used materials is not expected to be significant for conversion or storage for both U_3O_8 and UO_2 and would not affect local, regional, or national availability of these materials. Small to moderate amounts of specialty materials (i.e., Monel, Inconel, and titanium) would be required for construction of conversion facilities; no specialty materials would be required for construction or operation of a long-term storage facility. In general, facility operational requirements are not resource intensive, and the resources required are not considered rare or unique. However, for storage in a mine, large quantities of electrical energy would be required during construction (up to 1,000 MW-yr) because the majority of the construction equipment required to build the underground portion would be powered by electricity. The impact of this high electrical requirement on local energy resource use would depend on the location of the facility and the existing infrastructure. If a previously existing mine were used for storage, excavation and construction requirements would probably be reduced, and, depending on the characteristics and condition of the mine, the electrical requirements might also be reduced.

5.3.9 Land Use

Potential impacts for continued storage and cylinder preparation at the current storage sites would be the same as those discussed in Section 5.2.9. Impacts on land use for conversion and long-term storage facilities would depend on the locations of the facilities. The amount of land required would range from about 30 to 40 acres (12 to 16 ha) for conversion, 120 to 210 acres (49 to 85 ha) for long-term storage as U_3O_8, and 75 to 110 acres (30 to 45 ha) for long-term storage as UO_2, constituting potential land use impacts ranging from negligible to moderate. A protective action distance for emergency planning would need to be established around a conversion facility. This protective action distance would incorporate an area of about 960 acres (380 ha) around the facility. For storage in a mine, on-site topographical modifications associated with the disposition of excavated material could potentially affect future on-site land use. The potential for such impacts would be evaluated in the Phase II analyses and NEPA reviews. Impacts to land use outside the boundaries of facilities would be limited to temporary traffic impacts associated with construction.

5.3.10 Cultural Resources

Potential impacts to cultural resources during continued cylinder storage and cylinder preparation activities at the three current storage sites would be the same as those discussed in Section 5.2.10. The impacts to cultural resources for conversion and long-term storage facilities cannot be determined until the locations of the facilities are selected. However, impacts to cultural resources would be evaluated in Phase II studies and avoided if necessary and appropriate.

5.3.11 Environmental Justice

Potential environmental justice impacts from continued cylinder storage and cylinder preparation activities at the three current storage sites would be the same as those discussed in Section 5.2.11. Potential environmental justice impacts to minority and low-income populations from the construction and operation of conversion and long-term storage facilities would depend on the locations of these facilities. Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents will affect minority or low-income populations disproportionately.

5.4 USE AS URANIUM OXIDE

The use as uranium oxide alternative considers the use of 100% of the depleted UF_6 inventory. Under the use as uranium oxide alternative, it was assumed for assessment purposes that the depleted UF_6 would be converted to UO_2, which would be used in the manufacture of casks for storing spent nuclear fuel or HLW. (Although storage casks were assumed for assessment purposes, other uses for depleted uranium are possible). The uranium oxide in the storage casks would serve as radiation shielding. The casks would be transported to a user facility, such as a commercial nuclear power plant or DOE facility, where they would be used to store spent nuclear fuel or HLW. To provide a conservative estimate of potential transportation and construction impacts, the conversion, manufacturing, and use facilities were assumed to be at different locations. Issues associated with depleted uranium management after use are discussed in Section 5.9.

The following is a summary of the activities analyzed under the use as uranium oxide alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage would continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped to an independent conversion facility. The cylinder management activities that would occur at the sites were assumed to be similar to the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** Two cylinder preparation options were considered for cylinders not meeting transportation requirements: (1) a cylinder overcontainer option and (2) a cylinder transfer option (see Appendix E). The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three sites.

- ***Conversion (Representative Site).*** Conversion of UF_6 to an oxide, assumed to be UO_2 for assessment purposes, was assumed to occur from 2009 through 2028 at a newly constructed, stand-alone conversion facility.[2] As described in Appendix F, three representative conversion technologies were assessed for conversion to UO_2. The principal product of conversion would be either anhydrous HF, which would be shipped to a user facility, or CaF_2, which could be shipped for use or disposal.

- ***Transportation (Representative Routes).*** All UF_6 cylinders were assumed to be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to an independent conversion site. Following conversion, the UO_2 produced was assumed to be transported in drums by truck or rail to a manufacturing site. In addition, HF or CaF_2 would require transportation to

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[2] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

either a user or disposal facility. The uranium-oxide-shielded casks were assumed to be transported by rail from the manufacturing facility to a user site.

- ***Manufacture and Use (Representative Site).*** The manufacture of uranium oxide shielded casks was assumed to take place at a stand-alone facility dedicated to the cask manufacturing process. Casks would be manufactured and sent to a user facility, such as a nuclear power plant or DOE facility, where they would be used to store spent nuclear fuel or HLW. Manufacturing was assumed to occur concurrently with conversion (i.e., from 2009 through 2028). Preoperation of manufacturing facilities would occur between 1999 and 2008 (with actual construction requiring 7 years).

During use of depleted-uranium-concrete casks, impacts would be expected to be negligible. No release of depleted uranium would be expected during use because the uranium would be a solid material encased between thick stainless steel shells. In addition, radiation emitted from the uranium shielding material would be shielded by the steel cask shells and would be negligible compared with the highly radioactive spent nuclear fuel or HLW contained within the casks during use. Finally, the use of a radiation shield implies that there would be a net benefit because the radiation levels would be reduced.

5.4.1 Human Health and Safety

During implementation of the use as oxide alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. The principal facilities involved include the current storage sites, a conversion facility, and a cask manufacturing facility. Potential impacts are discussed in Sections 5.4.1.1 and 5.4.1.2.

5.4.1.1 Normal Facility Operations

5.4.1.1.1 Workers

The total radiation exposure of involved workers under the use as uranium oxide alternative would be greater than under the no action alternative because of the additional activities required for preparation of cylinders for shipment, conversion operations, and manufacture of oxide-shielded storage casks for use. At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting, cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a conversion facility would be exposed to radiation while handling incoming cylinders, during conversion operations, and while handling uranium oxide. At a cask manufacturing facility, involved workers would be exposed to radiation during the manufacture of casks. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

The number of potential radiation-induced LCFs among involved workers from 1999 through 2039 was estimated to range from about 1 to 2, compared with 1 for the no action alternative. In addition to about 60 cylinder yard workers, between 290 and 470 involved workers would be required for the use as oxide alternative (the exact number would depend on the cylinder preparation and conversion options selected). Impacts to noninvolved workers would be negligible compared to those for the involved workers (i.e., less than 1% of the involved worker impacts).

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations would not be expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, they would be provided with appropriate protective equipment, as necessary. The potential chemical exposure of noninvolved workers from airborne releases during normal operations were estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, and at a cask manufacturing facility).

5.4.1.1.2 General Public

The potential impacts to members of the general public during normal operations would be similar to the no action alternative — all exposures were estimated to be within applicable public health standards. No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites, near a conversion facility, or near a cask manufacturing facility from depleted UF_6 management activities. At the current storage sites, potential impacts to the members of the general public would be the same as described in Section 5.2.1.1.2 for the long-term storage as UF_6 alternative.

At an oxide conversion facility, members of the general public could potentially be exposed to small amounts of uranium and HF released to the air during normal operations. The total collective radiation dose to the general public from airborne emissions was estimated to range from about 2 to 10 person-rem over the operational period of the conversion facility (2009 through 2028). This range takes into account the different UO_2 conversion options and environmental settings considered (see Appendix F). This level of exposure was estimated to most likely result in zero LCFs among the general public. The maximum radiation dose to an individual near a UO_2 conversion site was estimated to be less than about 0.03 mrem/yr from airborne emissions, well within the applicable health standards (see Section 5.2.1.1.2). If an individual were to receive the maximum estimated dose every year the conversion facility operated (2009 through 2028), the total dose would be about 1 mrem, and the resulting chance of dying from a radiation-induced latent cancer would be less than 1 in 1 million. No noncancer health effects from exposure to airborne uranium and HF releases would be expected — the hazard index for an individual near a conversion facility was estimated to be less than 0.0002.

At a cask manufacturing facility, the potential exposure of members of the general public to radiation or chemicals was estimated to be much less than at a conversion facility. The total radiation dose to the general public (2009 through 2028) was estimated to be about 0.1 person-rem, which would be expected to most likely result in zero LCFs. The maximum radiation dose to an individual near a manufacturing site was estimated to be less than 0.001 mrem/yr from airborne emissions, well within the applicable health standards (see Section 5.2.1.1.2). No noncancer health effects from chemical exposures would be expected — the hazard index for an individual near a manufacturing facility was estimated to be less than 0.00001.

5.4.1.2 Facility Accidents

5.4.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related fatalities and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured during the use as oxide alternative, unrelated to any radiation or chemical exposures.

The number of accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries. The estimated number of worker fatalities and injuries would be greater than under the no action alternative because of the additional construction and operational activities required for cylinder preparation, conversion, and cask manufacturing facilities. The number of fatalities and injuries would depend on the specific cylinder preparation and conversion options.

Considering all conversion and manufacturing options, from 2 to 3 total accidental worker fatalities were estimated over the 41-year period. Approximately 1,300 to 2,000 injuries (defined as injuries resulting in lost workdays) were estimated from construction and operation of facilities over the same period. At the current storage sites, the maximum total number of injuries was estimated to be about 700, assuming that a cylinder transfer facility would be constructed and operated at each site. If cylinder overcontainers were used as the cylinder preparation option, a maximum of about 150 worker injuries were estimated at the three sites combined. Approximately 660 worker injuries were estimated to occur at a conversion facility (including treatment of empty cylinders), and approximately 640 worker injuries were estimated to occur at a cask manufacturing facility. These rates would not be unique to the activities required for the alternative, but would be typical of any industrial project of similar size and scope.

5.4.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the use as oxide alternative, accidents potentially releasing radiation and chemicals could occur at the three current storage sites (during continued cylinder storage through 2028), at an oxide conversion site, and at a cask manufacturing site. At each site, a range of accidents was evaluated, from those considered reasonably likely to occur (once or more in 100 years on average) to those that would be extremely rare (expected to occur less than once in 1 million years on average). The accidents considered are described in Appendix D, Section D.2.2, for continued cylinder storage; Appendix F, Section F.3.2, for conversion; and Appendix H, Section H.3.2, for cask manufacturing.

The potential consequences of cylinder accidents at the current storage sites and accidents at an oxide conversion facility are described in Section 5.1.1.2.2 for the no action alternative and in Section 5.3.1.2.2 for the long-term storage as oxide alternative. Although the use as oxide alternative would involve only conversion to UO_2, compared to UO_2 and U_3O_8 for the long-term storage as oxide alternative, the only difference in the results of the accident assessment would be in the radiological consequences for an earthquake accident at a conversion facility. The consequences of that accident were estimated to be somewhat less at a UO_2 conversion facility than at a U_3O_8 conversion facility (see Appendix F, Tables F.8 and F.9).

At a uranium oxide cask manufacturing facility, the potential consequences of all the accidents considered were estimated to be much less than potential conversion or cylinder accidents (see Appendix H, Section H.3.2). For all cask manufacturing accidents, chemical exposures of noninvolved workers and members of the general public were estimated to be much less than levels expected to cause adverse effects. The radiation dose to a maximally exposed noninvolved worker from an accident was estimated to be about 80 mrem, with a corresponding risk of death from cancer of about 1 chance in 30,000 (0.00003). The dose to a maximally exposed member of the general public was estimated to be less than 3 mrem, considerably below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents. The risk of death from cancer to an individual from this dose would be about 1 chance in 1 million. No LCFs were estimated to occur among noninvolved workers or members of the general public for the highest consequence accident evaluated. As described in Section 4.3.2.1, fatalities and injuries among involved workers are possible for all accidents.

5.4.2 Transportation

The major materials assumed to be transported under the use as oxide alternative are summarized in Table 5.7. The transportation activities for the use as oxide alternative would be very similar to those described for the long-term storage as oxide alternative in Section 5.3.2. For both alternatives, it was assumed that cylinders would be transported from the current storage sites to an oxide conversion facility. The two alternatives differ in the destination of the uranium oxide after conversion: it would be shipped either to a long-term storage facility or to a cask manufacturing

TABLE 5.7 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Use as Oxide Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Conversion site	46,422	11,600[d]	2	1
Uranium oxide (UO_2)	Conversion site	Manufacturing site	26,260 – 26,800	8,480 – 8,800	1	1
Ammonia	Supplier	Conversion site	–	960 – 1,120 (UO_2 conversion)	0	0
Anhydrous HF (if produced)	Conversion site	User	–	4,860	0	0
CaF_2 (if HF neutralized)	Conversion site	User or disposal site	19,800	7,300	1	0
LLW/LLMW	Current storage/ conversion/manu-facturing sites	Treatment/disposal site	1,220 – 2,680	–	0	0
Casks	Manufacturing site	User	–	9,600	–	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Colocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments assuming that either the truck or rail mode was used.

[c] Number of estimated traffic accident fatalities assuming each shipment traveled 620 miles (1,000 km) and using national average accident statistics. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

facility. However, because the locations of future long-term storage and cask manufacturing sites will be decided in Phase II of the management program, in both cases the potential impacts from these shipments were estimated assuming a representative route of 620 miles (1,000 km). Although the long-term storage as oxide alternative would involve both U_3O_8 and UO_2, the transportation risks would be very similar for shipments of U_3O_8 and UO_2 (see Appendix J, Section J.3.5, Tables J.11 through J.14). Consequently, the estimated impacts from shipments of oxide under the use as oxide alternative are almost identical to the impacts discussed in Section 5.3.2 for the long-term storage as oxide alternative. Both alternatives would also require the transportation of essentially the same amounts of process chemicals (ammonia), products of conversion (anhydrous HF or CaF_2), and waste generated during processing. Thus, the potential impacts for shipments of these materials would be the same as those described in detail in Section 5.3.2 during both normal conditions and accidents.

In addition to the materials and impacts discussed in Section 5.3.2, the use as oxide alternative would also require the shipment of casks from the manufacturing facility to a user. These casks, because of their large size, were assumed to be shipped by rail. A maximum of about 9,600 railcar shipments would be required to transport all the casks to users. The risk associated with cask shipments would be from typical traffic accidents, unrelated to the depleted uranium contained in the casks (external radiation dose rates would be extremely low near a cask and only negligible releases of uranium would be expected in extremely severe accidents because the uranium would be a solid encased between steel shells). If the 9,600 casks were shipped by rail over a distance of 620 miles (1,000 km), it was estimated on the basis of rail accident statistics that less than 1 traffic fatality would result. For comparison, shipment of all the cylinders, uranium oxide, and associated materials was estimated to potentially result in between 2 and 4 traffic fatalities, depending on whether truck or rail shipments would be used (see Section 5.3.2). Consequently, the estimated overall risks from transportation for the use as oxide alternative are essentially the same as those described for the long-term storage as oxide alternative.

5.4.3 Air Quality

The analysis of potential impacts on air quality from the use as oxide alternative considered the potential for air pollutant emissions from continued cylinder storage activities occurring through 2028, cylinder preparation activities, conversion, and manufacturing activities. For continued cylinder storage and cylinder preparation activities at the current sites, impacts would be identical to those discussed for the long-term storage as UF_6 alternative (Section 5.2.3). At a conversion facility, air quality impacts would be the same as discussed under the long-term storage as oxide alternative (Section 5.3.3).

At a cask manufacturing facility, air quality impacts would depend on the actual facility location; however, concentrations of criteria pollutants were all estimated to be within standards at the representative sites considered. Concentrations of criteria pollutants were estimated to be less than 9% of standards during construction and operations. The oxide cask manufacturing facility would emit 0.02 lb/yr (0.008 kg/yr) of uranium as UO_2. No air quality standards exist for uranium compounds; however, the potential health impacts of these emissions were evaluated in Section 5.4.1.1.

5.4.4 Water and Soil

Water use from continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.4. At a conversion facility, water use would be the same as described in Section 5.3.4. At a cask manufacturing facility, water use during facility construction (duration of about 7 years) would be 35 million gal/yr, and water use during operations would be about 7.5 million gal/yr. Wastewater generation would range from about 5 million gal/yr during operations to 8 million gal/yr during construction.

5.4.4.1 Surface Water

Under the use as oxide alternative, potential impacts on surface water at the current storage sites during continued storage of the cylinders and cylinder preparation would be the same as discussed for storage as UF_6 (Section 5.2.4.1). At a conversion facility, potential impacts to surface water would be the same as discussed for long-term storage as oxide (Section 5.3.4.1).

At a cask manufacturing facility, water use and wastewater generation during operations would be less than half that required for a conversion facility. Impacts to surface water would depend on the actual location of the facility.

5.4.4.2 Groundwater

Potential impacts on groundwater quality for continued cylinder storage through 2028 and for cylinder preparation activities at the three current storage sites would be the same as discussed in Section 5.2.4.2. At a conversion facility, the potential impacts would be the same as discussed in Section 5.3.4.2. Groundwater impacts at a cask manufacturing facility would depend on the size of the site in comparison with the size of the facility, on the proximity of the site to a river with relatively large flow volume (i.e., large in comparison with annual water use and wastewater discharge), and on whether the manufacturing facility water would be drawn from a surface water source or from groundwater. Because discharges to groundwater are not planned for these facilities (effluents would be released to nearby surface waters), there would be no direct impacts on groundwater quality. Good engineering and construction practices would be followed to minimize the potential for adverse effects during construction.

5.4.4.3 Soil

Potential impacts on soil at the current storage sites and at a conversion facility would be the same as discussed in Sections 5.2.4.3 and 5.3.4.3, respectively. Potential impacts at a manufacturing facility would depend on the actual location of the facility. Depending on the location of facilities and the amount of land area available, construction activities could cause changes in site topography, permeability, erosion potential, and soil quality. However, mitigative actions (e.g., contouring and reseeding excavated material, construction of retention basins, and prompt cleanup of chemical spills) would probably result in negligible impacts to soil.

5.4.5 Socioeconomics

Potential socioeconomic impacts associated with continued cylinder storage through 2028 and with cylinder preparation activities at the three current storage sites are discussed in Section 5.2.5. Socioeconomic impacts for an oxide conversion facility are summarized in Section 5.3.5.

The potential socioeconomic impacts of construction and operation of an oxide cask manufacturing facility would depend on the facility location. Construction of a cask manufacturing facility would create 160 direct jobs and $7 million in direct income during the peak year of construction. Operation of the facility would create 470 direct jobs and produce $33 million in direct income in each year of facility operation.

5.4.6 Ecology

Potential ecological impacts of continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.6. Potential impacts at a conversion facility would be the same as discussed in Section 5.3.6.

A cask manufacturing facility would require about 90 acres (36 ha). Existing vegetation at the site would be destroyed during land-clearing activities. In addition, wildlife could be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the location of the facility; in general, a loss of 90 acres would constitute a potential moderate adverse impact in terms of habitat loss. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility location. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Facility and transportation accidents (see Sections 5.4.1 and 5.4.2) 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 accident, season, and meteorological conditions.

5.4.7 Waste Management

The waste management impacts of continued cylinder storage and cylinder preparation at the current sites are discussed in Section 5.2.7; waste management impacts at a conversion facility, including treatment of empty cylinders, are discussed in Section 5.3.7.

The operation of a cask manufacturing facility would generate about 130 m^3/yr of LLW, 290 m^3/yr of hazardous waste, and 250 metric tons/yr of nonradioactive, nonhazardous solid waste; an additional 72 m^3 of hazardous waste and 60,000 m^3 of nonradioactive, nonhazardous solid waste would be generated during construction. The LLW generated would be only about 0.2% of the LLW projected annual treatment volume for all DOE facilities nationwide (i.e., 68,000 m^3/yr; see Appendix C, Section C.10).

5.4.8 Resource Requirements

Resource requirements for continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.8. Resource requirements for a conversion facility are discussed in Section 5.3.8. For a cask manufacturing facility, the total quantity of commonly used materials required for construction and operation would not be significant. Specialty materials would not be required. In general, facility operational requirements are not resource intensive and the resources required are not considered rare or unique.

5.4.9 Land Use

Land-use impacts from continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.9. Impacts on land use for conversion are discussed in Section 5.3.9. The amount of land required would be about 90 acres (36 ha) for a cask manufacturing facility, constituting potential moderate land use impacts. The potential for such impacts would be evaluated in the site-specific Phase II studies and NEPA reviews. Impacts to land use outside the boundaries of facilities would consist of potential temporary traffic impacts associated with project construction.

5.4.10 Cultural Resources

Potential impacts to cultural resources from continued cylinder storage and cylinder preparation activities at the three current storage sites are discussed in Section 5.2.10. The impacts to cultural resources for conversion and manufacturing facilities would depend on the specific locations of the facilities. Impacts to cultural resources would be evaluated in Phase II studies and avoided as necessary and appropriate.

5.4.11 Environmental Justice

Potential environmental justice issues related to continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as those discussed in Section 5.2.11 for the long-term storage as UF_6 alternative. Potential environmental justice impacts to minority and low-income populations from the construction and operation of conversion and manufacturing facilities would depend on the actual locations of these facilities. Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents will affect minority or low-income populations disproportionately.

5.5 USE AS URANIUM METAL

The use as metal alternative considers the use of 100% of the depleted UF_6 inventory. The use as uranium metal alternative would be very similar to the use as oxide alternative, except under the metal alternative, the depleted UF_6 would be converted to uranium metal, which was assumed to be used in the manufacture of casks for storing spent nuclear fuel or HLW. The uranium metal would serve as radiation shielding. The casks would be transported to a user facility, such as a commercial nuclear power plant or DOE facility, where they would be used to store spent nuclear fuel or HLW. Issues associated with the management of depleted uranium after use are discussed in Section 5.9.

The following is a summary of the activities analyzed under the use as uranium metal alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage would continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped to an independent conversion facility. The cylinder management activities that would occur at the sites were assumed to be similar to the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** Two cylinder preparation options were considered for cylinders not meeting transportation requirements: (1) a cylinder overcontainer option and (2) a cylinder transfer option (see Appendix E). The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three sites.

- ***Conversion (Representative Site).*** Conversion of UF_6 to uranium metal was assumed to occur from 2009 through 2028 at a newly constructed, stand-alone conversion facility.[3] As described in Appendix F, two representative conversion technologies were assessed for conversion to uranium metal. The principal product of conversion would be either HF, which would be shipped to a user facility, or CaF_2, which could be shipped for use or disposal. In

[3] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

addition, conversion to metal would also potentially produce MgF_2, which would be disposed of as nonhazardous, nonradioactive waste or LLW. | |

- ***Transportation (Representative Routes).*** For assessment purposes, it was assumed that all UF_6 cylinders would be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to an independent conversion site. Following conversion, the uranium metal produced would be transported by truck or rail to a manufacturing site. In addition, MgF_2 and either HF or CaF_2 would require transportation to either a user or disposal facility. The casks would be transported by rail from the manufacturing facility to a user site. | |

- ***Manufacture and Use (Representative Site).*** The manufacture of uranium-metal-shielded casks was assumed to take place at a stand-alone facility dedicated to the cask manufacturing process (see Appendix H). Casks would be fabricated and sent to a user facility, such as a nuclear power plant or DOE facility, where they would be used to store spent nuclear fuel. Manufacturing was assumed to occur concurrently with conversion (i.e., from 2009 through 2028). Preparation of manufacturing facilities would occur between 1999 and 2008 (with actual construction requiring 7 years).

The potential environmental consequences of all of the activities under the use as metal alternative, as outlined above, are discussed in Sections 5.5.1 through 5.5.11.

5.5.1 Human Health and Safety

During implementation of the use as metal alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. The principal facilities involved include the current storage sites, a conversion facility, and a cask manufacturing facility. These impacts are discussed in Sections 5.5.1.1 and 5.5.1.2.

5.5.1.1 Normal Facility Operations

5.5.1.1.1 Workers

The total radiation exposure of involved workers under the use as uranium metal alternative would be greater than under the no action alternative because of the additional activities required for preparation of cylinders for shipment, conversion operations, and manufacture of metal-shielded casks for use. At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting, cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a metal conversion facility would be exposed to radiation while handling incoming cylinders, during conversion operations, and while handling uranium metal. At a cask manufacturing facility, involved workers would be exposed to radiation during the manufacture of casks. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

The number of potential radiation-induced latent cancer fatalities among involved workers from 1999 through 2039 was estimated to range from about 1 to 2, compared with 1 for the no action alternative. In addition to about 60 cylinder yard workers, from 390 to 690 involved workers would be required for the use as metal alternative (the exact number would depend on the cylinder preparation and conversion options selected). Impacts to noninvolved workers would be negligible compared to those for involved workers (i.e., less than 1% of the involved worker impacts).

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations would not be expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, they would be provided with appropriate protective equipment as necessary. The potential chemical exposure of noninvolved workers from any airborne releases during normal operations were estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, and a cask manufacturing facility).

5.5.1.1.2 General Public

The potential impacts to members of the general public during normal operations for the use as metal alternative would be similar to the no action alternative — all exposures were estimated to be within applicable public health standards (40 CFR Part 61; DOE Order 5400.5). No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites, near a metal conversion facility, or near a cask manufacturing facility from depleted UF_6 management activities. At the current storage sites, potential impacts to members of the general public under the use as uranium metal alternative would be the same as described in Section 5.2.1.1.2.

At a metal conversion facility, members of the general public could potentially be exposed to small amounts of uranium and HF released to the air during normal operations. The total collective radiation dose to the general public from airborne emissions was estimated to range from about 0.3 to 8 person-rem over the operational period of the conversion facility (2009 through 2028). This range takes into account the different metal conversion options and environmental settings considered (see Appendix F). This level of exposure was estimated to most likely result in zero LCFs among members of the general public. The maximum radiation dose to an individual near a metal conversion site was estimated to be less than 0.03 mrem/yr from airborne emissions, well within the applicable health standards (see Section 5.2.1.1.2). If an individual were to receive the maximum estimated dose every year the conversion facility operated (2009 through 2028), the total dose would be about 1 mrem, and the resulting chance of dying from a radiation-induced latent cancer would be less than 1 in 1 million. No noncancer health effects from exposure to airborne uranium and HF releases would be expected — the hazard index for an individual near a conversion facility was estimated to be less than 0.0002.

At a cask manufacturing facility, the potential exposure of members of the general public to radiation or chemicals was estimated to be much less than at a conversion facility. The total radiation dose to the general public (2009 through 2028) was estimated to be about 0.7 person-rem, resulting in zero LCFs. The maximum radiation dose to an individual near a manufacturing site was estimated to be less than 0.002 mrem/yr from airborne emissions, well within applicable health standards (see Section 5.2.1.1.2). No noncancer health effects from chemical exposures would be expected — the hazard index for an individual near a manufacturing facility was estimated to be less than 0.00001.

5.5.1.2 Facility Accidents

5.5.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured during the use as metal alternative, unrelated to any radiation or chemical exposures.

The number of accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries. The estimated number of worker fatalities and injuries would be greater than under the no action alternative because of the additional construction and operational activities required for cylinder preparation, conversion, and cask manufacturing facilities. The number of fatalities and injuries would depend on the specific cylinder preparation and conversion options.

The number of accidental fatalities and injuries would be similar to the use as oxide alternative; a total of 2 to 3 accidental worker fatalities were estimated over the 41-year period. Approximately 1,300 to 2,100 injuries (defined as injuries resulting in lost workdays) were estimated from construction and operation of facilities over the same period. At the current storage sites, the maximum total number of injuries was estimated to be about 700, assuming that a cylinder transfer facility would be constructed and operated at each site. If cylinder overcontainers were used as the cylinder preparation option, a maximum of about 150 worker injuries were estimated at the three sites combined. Approximately 660 worker injuries were estimated to occur at a conversion facility (including treatment of empty cylinders), and approximately 670 worker injuries were estimated to occur at a cask manufacturing facility. These rates would not be unique to the activities required for the alternative, but would be typical of any industrial project of similar size and scope.

5.5.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the use as metal alternative, accidents potentially releasing radiation and chemicals could occur at the three current storage sites (during continued cylinder storage through 2028), at a metal conversion site, and at a cask manufacturing site. For each site, a range of accidents was evaluated, from those considered reasonably likely to occur (once or more in 100 years on average) to those that would be extremely rare (expected to occur less than once in 1 million years on average). The accidents considered are described in Appendix D, Section D.2.2, for continued cylinder storage; Appendix F, Section F.3.2, for conversion; and Appendix H, Section H.3.2, for cask manufacturing.

The potential consequences of cylinder accidents at the current storage sites and accidents at an oxide conversion facility are discussed in Section 5.1.1.2.2 for the no action alternative and in Section 5.3.1.2.2 for the long-term storage as oxide alternative. For the use as metal alternative, UF_6 would be converted to uranium metal rather than uranium oxide. However, the types and consequences of accidents at a metal conversion facility would be generally similar to those at an oxide conversion facility (see Appendix F, Section F.3.2). Differences between oxide conversion and metal conversion accident consequences are highlighted below.

For conversion to metal, the most severe chemical accidents would be the same as described for conversion to oxide: rupture of either an ammonia tank or an HF tank. The potential consequences of these low-probability accidents are described in Section 5.3.1.2.2. Among the accidents considered likely to occur at each facility, metal conversion accidents were estimated to have slightly lower chemical consequences to workers compared with oxide conversion accidents. At most, 5 noninvolved workers were estimated to experience potential irreversible adverse effects from likely metal conversion accidents, compared with 40 during conversion to oxide, with no noninvolved worker fatalities (this difference results because conversion to metal would not involve a potential ammonia stripper accident). For both conversion to oxide and metal, members of the general public would not be expected to experience adverse effects from likely accidents because off-site concentrations of released materials were estimated to be below levels expected to cause such effects. Injuries and fatalities among involved workers are possible for all accidents (see Section 4.3.1).

For the metal conversion accidents considered likely to occur, the consequences from radiation exposures would be the same as those described in Section 5.3.1.2.2. However, the radiological consequences of the most severe (low-probability) metal conversion accidents were estimated to be much less than those described for conversion to oxide accidents in Section 5.3.1.2.2.

Much of the difference in predicted consequences between accidents involving U_3O_8 and accidents involving uranium metal is associated with the form of the material. U_3O_8 is an easily dispersed powder, whereas on uranium metal billets, only the oxide coating can be readily dispersed. Therefore, the assumed release amounts for some of the accidents at metal conversion facilities are considerably lower than those assumed for oxide conversion facilities. At a metal conversion facility, the accident estimated to have the highest consequences from radiation exposures would be a fire involving three UF_6 cylinders, which is considered extremely unlikely (estimated to occur between once in 10,000 years and once in 1 million years). If this accident occurred, the radiation dose to a maximally exposed member of the general public was estimated to be about 15 mrem (compared with 270 mrem for the highest-consequence oxide conversion accident), resulting in an increased risk of death from cancer of about 7 in 1 million. The total population dose to the general public within 50 miles (80 km) was estimated to be 56 person-rem, resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to be about 20 mrem (compared with 9,000 mrem for oxide conversion), resulting in an increased risk of death from cancer of about 8 in 1 million. The total dose to all noninvolved workers was estimated to be about 8 person-rem, resulting in zero LCFs.

At a uranium metal cask manufacturing facility, the potential consequences of the accidents considered were estimated to be less than those for potential conversion or cylinder accidents (see Appendix H). For all likely accidents, chemical concentrations were estimated to be below levels that would cause adverse effects among workers and members of the general public. In addition, the chance of a radiation-induced cancer fatality among noninvolved workers and members of the general public was estimated to be much less than 1 in 1 million if a likely accident occurred.

The metal cask manufacturing facility accident estimated to have the highest potential consequences was an accident involving the failure of a uranium metal furnace caused by an earthquake. Such an accident is considered incredible, occurring less than once in 1 million years. If such an accident occurred, it was estimated that up to 1 member of the general public and 4 noninvolved workers could experience adverse effects from chemical exposures, with no fatalities expected. If this accident occurred, the radiation dose to a maximally exposed member of the general public was estimated to be about 7 mrem, resulting in an increased risk of death from cancer of about 4 in 1 million. The total population dose to the general public within 50 miles (80 km) was estimated to be 1.9 person-rem, resulting in zero LCFs. Among noninvolved workers, the dose to an MEI was estimated to range up to 230 mrem, resulting in an increased risk of death from cancer of about 9 in 100,000. The total dose to all noninvolved workers was estimated to be about 0.087 person-rem. (The dose to the MEI noninvolved worker was estimated to be greater than the population dose among workers because the MEI worker was assumed to be at the location of maximum possible impact, very close to the accident. The worker population distribution was assumed to be evenly distributed over a large area.) All doses would be considerably below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents.

5.5.2 Transportation

The major materials assumed to be transported under the use as metal alternative are summarized in Table 5.8. The transportation activities would be very similar to those described for the use as oxide alternative in Section 5.4.2. All cylinders were assumed to be transported from the current storage sites to a conversion facility. The uranium metal would be transported from the conversion facility to a cask manufacturing facility. The transportation of process chemicals (ammonia), products of conversion (anhydrous HF and MgF_2), and waste generated during processing would also be required. The casks were assumed to be transported from the manufacturing facility to a user by rail.

The overall impacts from transportation activities were estimated to be generally similar to those described for the long-term storage as oxide (Section 5.3.2) and use as oxide alternatives (Section 5.4.2). During normal transportation operations, it was estimated that up to 1 fatality could occur among workers and members of the general public from exposure to external radiation and vehicle exhaust emissions if truck shipments were used; if rail shipments were used, 0 fatalities were estimated during normal operations. The estimated number of fatalities from traffic accidents (unrelated to the cargo) are presented in Table 5.8. If truck shipments were used, it was estimated that about 3 traffic fatalities could result. If rail shipments were used, it was estimated that about 2 traffic fatalities could result. Rail transport results in a lower number of traffic fatalities, primarily because railcars have a larger shipment capacity than trucks, resulting in fewer shipments. The actual number of fatalities would be much less if the number of shipments and shipment distances were reduced. Details are provided in Appendix J.

Transportation risks would also be associated with the potential release of radiation or chemicals during accidents. The materials of greatest concern would be anhydrous HF, ammonia, and depleted UF_6 cylinders. The consequences and risks of accidents involving releases of these materials are described in detail in Section 5.3.2. Conversion to metal would result in about one-third the number of shipments of anhydrous HF compared with conversion to oxide.

5.5.3 Air Quality

The analysis of potential impacts to air quality for the use as metal alternative considered the potential for air pollutant emissions from continued cylinder storage activities occurring through 2028, cylinder preparation activities, conversion, and manufacturing activities. For continued cylinder storage and cylinder preparation activities at the current sites, impacts would be identical to those discussed for the long-term storage as UF_6 alternative (Section 5.2.3).

At a metal conversion facility, air quality impacts would depend on the actual facility location; however, estimated concentrations of criteria pollutants for the representative settings were all estimated to be within standards. Concentrations of the criteria pollutants and HF were estimated to be less than 20% of respective standards during construction and less than 5% of respective

TABLE 5.8 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Use as Metal Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Conversion site	46,422	11,600[d]	2	1
Uranium metal	Conversion site	Manufacturing site	20,840 – 21,500	7,360 – 7,520	1	0
Ammonia	Supplier	Conversion site	–	920	0	0
Anhydrous HF	Conversion site	User	–	1,640	0	0
MgF_2	Conversion site	Disposal site	10,320 – 10,780	3,800 – 3,980	0	0
LLW/LLMW	Current storage/ conversion/manu-facturing sites	Treatment/disposal site	2,460 – 6,060	–	0	0
Casks	Manufacturing site	User	–	9,060	0	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Colocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments assuming that either the truck or rail mode was used.

[c] Number of estimated traffic accident fatalities assuming each shipment traveled 620 miles (1,000 km) and using national average accident statistics. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

standards during operations. A metal conversion facility would emit between about 4 and 11 lb/yr (1.8 and 5 kg/yr) of uranium as either U_3O_8 or UF_4. No air quality standards exist for uranium compounds; however, potential impacts of these emissions were evaluated in Section 5.5.1.1.

At a metal cask manufacturing facility, impacts on criteria pollutant emissions from construction and operation would be identical to those discussed for the use of uranium oxide alternative (Section 5.4.3). The metal cask manufacturing facility would emit 0.1 lb/yr (0.05 kg/yr) of uranium as U_3O_8. No air quality standards exist for uranium compounds; however, the potential impacts of these emissions were evaluated in Section 5.5.1.1.

5.5.4 Water and Soil

Water use from continued cylinder storage and cylinder preparation activities at the three current storage sites would be the same as discussed in Section 5.2.4. At a metal conversion facility, water use during construction (duration of about 4 years) would be between 10 and 12 million gal/yr; maximum water use during operations would be about 55 million gal/yr. Wastewater generation would range from about 25 to 30 million gal/yr. At a cask manufacturing facility, water use during construction (duration of about 7 years) would be 43 million gal/yr, and water use during operations would be about 7 million gal/yr. Wastewater generation would range from about 5 million gal/yr during operations to 9 million gal/yr during construction.

5.5.4.1 Surface Water

Under the use as metal alternative, potential impacts on surface water at the current storage sites during continued cylinder storage and cylinder preparation would be the same as discussed for storage as UF_6 (Section 5.2.4.1). At a metal conversion facility, impacts to surface water would depend on the actual location of the facility. However, based on the assessment for the representative settings considered in the PEIS, impacts to runoff and floodplain encroachment would be negligible. Concentrations of uranium in effluents from a conversion facility would range from about 25 to 53 µg/L. After dilution in nearby surface water, concentrations would be much less than the guideline of 20 µg/L.

At a cask manufacturing facility, water use and wastewater generation during operations would be less than half that required for a conversion facility. Impacts to surface water would depend on the actual location of the facility.

5.5.4.2 Groundwater

Potential impacts on groundwater quality from continued cylinder storage through 2028 and cylinder preparation activities at the current storage sites are discussed in Section 5.2.4.2. For conversion to metal and for cask manufacturing, the impacts on groundwater would depend on the actual locations of the facilities. However, the assessment for conversion to metal at representative settings indicated that impacts on recharge, depth to groundwater, or direction of flow would probably be negligible (the maximum increase over current groundwater use at the representative settings was estimated to be 0.8%). Impacts to these parameters for the manufacturing facility would depend on the size of the site in comparison with the facility, on the proximity of the site to a river with relatively large flow volume (i.e., large in comparison with annual water use and wastewater discharge), and on whether the manufacturing facility water would be drawn from a surface water source or from groundwater. Because discharges to groundwater are not planned for either conversion or manufacturing facilities (effluents would be released to nearby surface waters), direct impacts to groundwater quality would be unlikely. Good engineering and construction practices would be followed to minimize the potential for adverse impacts on groundwater resources during construction.

5.5.4.3 Soil

Potential impacts on soil at the current storage sites would be the same as discussed in Section 5.2.4.3. Potential impacts on soil at conversion to metal and manufacturing facilities would depend on their actual locations. Depending on the location of facilities and the amount of land area available, construction activities could cause changes in site topography, permeability, erosion potential, and soil quality. However, mitigative measures (e.g., contouring and reseeding excavated material, construction of retention basins, and prompt cleanup of chemical spills) would result in the impacts to soil being negligible.

5.5.5 Socioeconomics

Potential socioeconomic impacts associated with continued cylinder storage through 2028 and with cylinder preparation activities at the current storage sites are discussed in Section 5.2). The potential socioeconomic impacts of construction and operational activities of a metal conversion facility (including impacts from cylinder treatment) would depend on the facility location. Construction activities would create short-term employment (480 to 540 direct jobs and 760 to 1,100 total jobs in the peak construction year); operational activities would create between 340 and 500 direct jobs and between 780 and 1,200 total jobs per year. Direct and total income in the peak construction year would range from $17 to $21 million and from $20 to $31 million, respectively. During operations, direct and total income would range from $20 to $28 million and from $28 to $41 million per year, respectively. Employment and income totals given include estimates for a cylinder treatment facility.

For the representative settings used for analysis, the employment and income created from conversion to metal would represent a change of less than 0.1% of projected growth in these indicators of overall regional activity. The in-migration expected into the region of a metal conversion facility would have only a low impact on regional population growth rates. A moderate impact to housing could occur, with about 22% of the projected number of vacant rental housing units in the representative ROIs being required. Low impacts on local public finances would be expected; with all increases over forecasted baseline revenues and expenditures being less than 1%.

The potential socioeconomic impacts of construction and operation of a metal cask manufacturing facility would depend on facility location. Construction would create 190 direct jobs and $9 million in direct income during the peak year of construction. Operation of the facility would create 470 direct jobs and produce $33 million in direct income in each year of facility operations.

5.5.6 Ecology

The potential ecological impacts of continued cylinder storage and cylinder preparation at the three current storage sites are discussed in Section 5.2.6. Depending on the types of facilities, construction would disturb about 30 to 35 acres (12 to 14 ha) for a metal conversion facility and 90 acres (36 ha) for a manufacturing facility. Existing vegetation at the conversion and manufacturing sites would be destroyed during land-clearing activities. In addition, wildlife would be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the locations of the facilities; in general, losses of 35 and 90 acres would constitute potential moderate adverse impacts in terms of habitat loss. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility locations. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Facility and transportation accidents could result in adverse impacts to ecological resources (see Sections 5.5.1 and 5.5.2). The affected species and degree of impact would depend on a number of factors such as location of accident, season, and meteorological conditions.

5.5.7 Waste Management

The waste management impacts of continued cylinder storage and cylinder preparation at the current storage sites are discussed in Section 5.2.7. During construction of the metal conversion facility, a maximum of approximately 180 m^3/yr of hazardous waste would be generated. During operations, about 190 to 1,900 m^3/yr of LLW, 1 m^3/yr of LLMW, and 7 to 10 m^3/yr of hazardous waste would be generated (ranges are the result of assessing different conversion technologies). Operation of the metal conversion facility would generate up to about 6,800 m^3/yr of nonradioactive, nonhazardous solid waste; about 90% of this would be MgF_2 produced in the conversion process. Nonradioactive, nonhazardous solid waste generation rates for conversion could exceed the current rates at the representative settings considered in the analysis, but the actual facilities would be designed to meet appropriate waste treatment demands. A cylinder treatment facility would also be required for the emptied cylinders; impacts of such a facility are discussed in Section 5.3.7.

It is possible that the MgF_2 waste generated would be sufficiently contaminated with uranium to require disposal as LLW rather than as nonradioactive, nonhazardous solid waste. The uranium level in the MgF_2 is estimated to be about 90 ppm (LLNL 1997a). Disposal as LLW might require the MgF_2 waste to be grouted, generating up to 12,300 m^3/yr of LLW for disposal. This volume would represent less than 6% of the projected DOE complexwide LLW disposal volume, constituting a low impact with respect to DOE complexwide LLW management if the LLW were considered to be DOE waste. For the metal conversion option, neutralization of HF to produce CaF_2 could result in approximately 3,500 m^3/yr of CaF_2. It is currently unknown if the CaF_2 would be sold, disposed of as nonradioactive, nonhazardous solid waste, or disposed of as LLW. If disposed of as

DOE LLW, the CaF_2 would constitute approximately 3% of the projected DOE complexwide LLW disposal volume.

The operation of a metal manufacturing facility would generate about 650 m^3/yr of LLW, 320 m^3/yr of hazardous waste, and 300 metric tons/yr of nonhazardous waste; an additional 80 m^3 of hazardous waste and 70,000 m^3 of nonradioactive, nonhazardous waste would be generated during construction. The LLW generated would be about 0.3% of the projected annual treatment volume for all DOE facilities nationwide.

5.5.8 Resource Requirements

Resource requirements for continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.8. Construction and operation of facilities under the use as metal alternative would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that are generally irretrievable resources. The total quantity of commonly used materials is not expected to be significant and would not affect local, regional, or national availability of these materials. Some specialty materials (i.e., up to 100 tons of Monel, 4 tons of Inconel, and 10 tons of titanium) would be required for construction of conversion facilities; specialty materials would not be required for construction of manufacturing facilities. In general, facility operational requirements are not resource intensive and the resources required are not considered rare or unique.

5.5.9 Land Use

Land-use impacts from continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.9. Impacts on land use for conversion and manufacture would depend on the locations of these facilities. The amount of land required would range from about 30 to 35 acres (12 to 14 ha) for a conversion facility and 90 acres (36 ha) for a manufacturing facility, constituting potential moderate land use impacts. A protective action distance for emergency planning would need to be established around a metal conversion facility. This protective action distance would incorporate an area of about 960 acres (384 ha) around the facility. The potential for such impacts would be evaluated in the Phase II studies and NEPA reviews. Impacts to land use outside the boundaries of facilities would consist of potential temporary traffic impacts associated with project construction.

5.5.10 Cultural Resources

Potential impacts to cultural resources from continued cylinder storage and cylinder preparation activities at the current storage sites are discussed in Section 5.2.10. The impacts to cultural resources for metal conversion and manufacturing facilities would depend on specific locations of the facilities. Impacts to cultural resources would be evaluated in Phase II studies and avoided if necessary and appropriate.

5.5.11 Environmental Justice

Potential environmental justice issues related to continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.11 for the long-term storage as UF_6 alternative. Potential environmental justice impacts to minority and low-income populations from the construction and operation of metal conversion and manufacturing facilities would depend on the locations of these facilities. Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents will affect minority or low-income populations disproportionately.

5.6 DISPOSAL AS URANIUM OXIDE

Under the disposal as uranium oxide alternative, depleted UF_6 would be chemically converted to a more stable oxide form and disposed of belowground as LLW. Prior to disposal, conversion of depleted UF_6 to an oxide was assumed to take place at a newly constructed, stand-alone facility dedicated to the conversion process. Potential disposal impacts were evaluated for two different uranium oxides, U_3O_8 and UO_2 (similar to the long-term storage as oxide alternative). Both oxide forms have low-solubility in water and are relatively stable over a wide range of environmental conditions (see Appendix A). For each form, several disposal options were considered, including disposal in shallow earthen structures, belowground vaults, and an underground mine. To provide a conservative estimate of potential impacts, the conversion and disposal facilities were assumed to be located at sites other than the three current cylinder storage sites. Thus, transportation of cylinders from the three current storage sites to a conversion facility, and transportation of uranium oxide from the conversion facility to a disposal facility, was assumed.

Two physical waste forms were considered in the PEIS, ungrouted and grouted uranium oxide. Ungrouted waste refers to U_3O_8 or UO_2 in the powder or pellet form produced during the conversion process. This bulk material would be disposed of in either 55-gal (208-L) drums for U_3O_8 or 30-gal (110-L) drums for UO_2. Grouted waste refers to the solid material obtained by mixing the uranium oxide with cement and repackaging it in drums. Grouting is intended to increase structural strength and stability of the waste and to reduce the solubility of the waste in water. However, because cement is added to the uranium oxide, grouting would increase the total volume requiring disposal. Grouting of waste was assumed to occur at the disposal facility.

The potential impacts from disposal were estimated for two phases: (1) the operational phase, which includes the construction and operation of facilities and is the period during which drums would be actively placed into disposal units, and (2) the post-closure phase, which extends up to 1,000 years in the future after the assumed failure of the disposal units. No matter how well designed, all disposal facilities would be expected to release material to the environment (or "fail") eventually. In general, shallow earthen structures would be expected to contain waste material for at least several hundred years before failure, and vaults and mines would be expected to last even longer. For purposes of analysis in this PEIS, failure of all three types of disposal facilities was assumed to occur at the end of a period of institutional control, 100 years after closure. Because of the infiltration of water, uranium could ultimately migrate through the soil and eventually contaminate the groundwater. The potential impacts during the post-closure phase would result from using contaminated groundwater that could affect members of the general public.

The estimated impacts associated with the disposal alternative are subject to a great deal of uncertainty — especially during the post-closure phase. In general, the degree of uncertainty associated with potential post-closure impacts is greater than that for the other impacts considered in the PEIS. The analysis of post-closure impacts considered an extremely long period of time and was based on predicting the behavior of the uranium material after disposal as it interacts with soil and water in a complex and changing environment. Consequently, the estimated impacts are very dependent on the assessment assumptions. Key assumptions included such factors as soil characteristics, water infiltration rates, depth to the underlying groundwater table, chemistry of different uranium compounds in the soil, and locations of future human receptors. These factors could vary widely, depending on site-specific conditions. In response, the assumptions used in the PEIS were generally selected in a manner intended to produce conservative estimates of impacts, that is, the assumptions tend to overestimate the potential impacts.

The following is a summary of the activities analyzed for the disposal as uranium oxide alternative:

- ***Continued Cylinder Storage (at Paducah, Portsmouth, and K-25).*** Depleted UF_6 cylinder storage would continue at each of the three current storage sites through 2028. The entire inventory would be stored at the sites through 2008, but the site inventory would decrease from 2009 through 2028 as cylinders were shipped off-site to an independent conversion facility. The cylinder management activities that were assumed to occur at the sites would be similar to the no action alternative.

- ***Preparation of Cylinders for Shipment (at Paducah, Portsmouth, and K-25).*** Two cylinder preparation options for cylinders not meeting transportation requirements were considered: (1) a cylinder overcontainer option and (2) a cylinder transfer option. The cylinder overcontainer option would not require the construction of any new facilities; for the cylinder transfer option, it was assumed that a transfer facility would be constructed at each of the three current storage sites.

- ***Conversion (Representative Site).*** Conversion was assumed to occur from 2009 through 2028 at a newly constructed, stand-alone conversion facility.[4] As described in Appendix F, two representative conversion technologies were assessed for conversion to U_3O_8, and three for conversion to UO_2. The principal product of conversion would be either anhydrous HF, which would be shipped to a user facility, or CaF_2, which could be shipped for use or disposal.

- ***Transportation (Representative Routes).*** All UF_6 cylinders were assumed to be transported by either truck or rail from the Paducah, Portsmouth, and K-25 sites to an independent conversion site. Following conversion, the U_3O_8 or UO_2 produced was assumed to be transported in drums by truck or rail to a disposal facility. In addition, HF and CaF_2 would require transportation to either a user or disposal facility.

- ***Disposal (Generic Site).*** Three options were considered for the disposal of oxide, including disposal in shallow earthen structures, vaults, or a mine (see Appendix G). Drums of oxide would be received and disposed of at the disposal facility from 2009 through 2028. Construction of the disposal units would continue over a 20-year period while the drums were being received. Grouting would also occur at the disposal facility, if necessary.

The potential environmental consequences of all of the activities under the disposal as uranium oxide alternative, as outlined above, are provided in Sections 5.6.1 through 5.6.11.

5.6.1 Human Health and Safety

During implementation of the disposal as oxide alternative, potential impacts to human health and safety could result from facility operations during both routine conditions and accidents. The principal facilities involved include the current storage sites, a conversion facility, and a disposal facility. These impacts are discussed in Sections 5.6.1.1 and 5.6.1.2.

5.6.1.1 Normal Facility Operations

5.6.1.1.1 Workers

The total radiation exposure of involved workers under the disposal as oxide alternative would be greater than under the no action alternative because of the additional activities required for

[4] These estimates were meant to provide a consistent analytical timeframe for the evaluation of all of the PEIS alternatives and do not represent a definitive schedule.

preparation of cylinders for shipment, conversion operations, and disposal operations. Impacts to workers would only occur during the operational phase of disposal.

At the three current storage sites, involved workers would be exposed to low-level radiation during routine cylinder monitoring and maintenance, cylinder relocation and painting, cylinder patching or repairing, and preparation of cylinders for shipment. Involved workers at a conversion facility would be exposed to radiation while handling incoming cylinders, during conversion operations, and while handling uranium oxide. At a disposal facility, involved workers would be exposed to radiation during the placement of drums of uranium oxide into the disposal areas or during the grouting of waste. At all facilities, radiation exposure of workers would be maintained in accordance with ALARA practices.

The estimated numbers of potential radiation-induced LCFs among involved workers from 1999 through 2039 are summarized in Figure 5.4, assuming that the oxide would be grouted before disposal, and in Figure 5.5, assuming that the oxide would not be grouted. A total of about 1 to 2 additional LCFs were estimated among the involved worker population, compared with 1 LCF for the no action alternative. (The impacts to noninvolved workers were estimated to be negligible compared to involved workers.) The impacts to involved workers would be similar for the disposal of U_3O_8 and UO_2, with slightly higher doses estimated for the disposal of grouted waste compared to ungrouted waste because of the additional worker activities required by grouting. The impacts to involved workers also would be similar for disposal in shallow earthen structures, vaults, or a mine because all three options would involve handling the same amount of radioactive material and require the same general types of activities.

Impacts to involved and noninvolved workers from exposure to chemicals during normal operations would not be expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, they would be provided with appropriate protective equipment as necessary. The potential chemical exposure of noninvolved workers from airborne releases during normal operations were estimated to be below levels expected to cause adverse effects (the estimated hazard indices were less than 0.002 for noninvolved workers at all three current storage sites, a conversion facility, and a disposal facility).

5.6.1.1.2 General Public

Potential impacts to members of the general public were estimated for the operational phase of the disposal as oxide alternative, which is the time that UF_6 would be converted to oxide and actively disposed of, and for the post-closure (long-term) phase, defined to be within 1,000 years in the future after the disposal facility was assumed to fail.

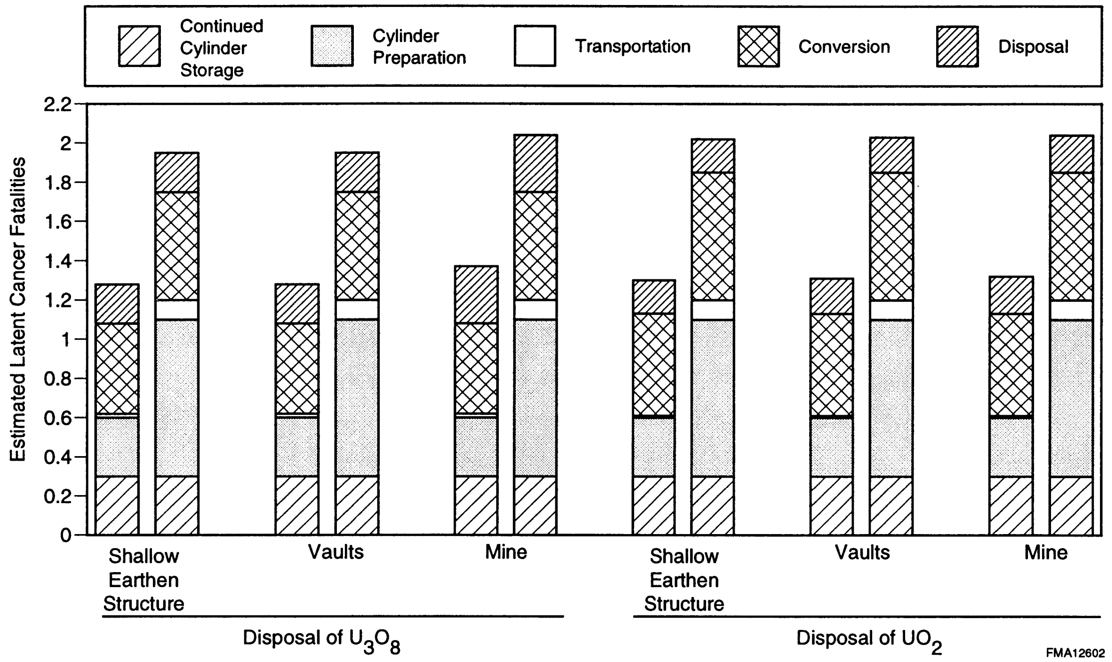

FIGURE 5.4 Total Estimated Number of LCFs among Involved Workers from Radiation Exposures during Normal Operations for the Disposal as Oxide Alternative, Assuming Grouted Waste, 1999 through 2039 (Note: The two bars presented for each option represent the minimum and maximum impacts estimated.)

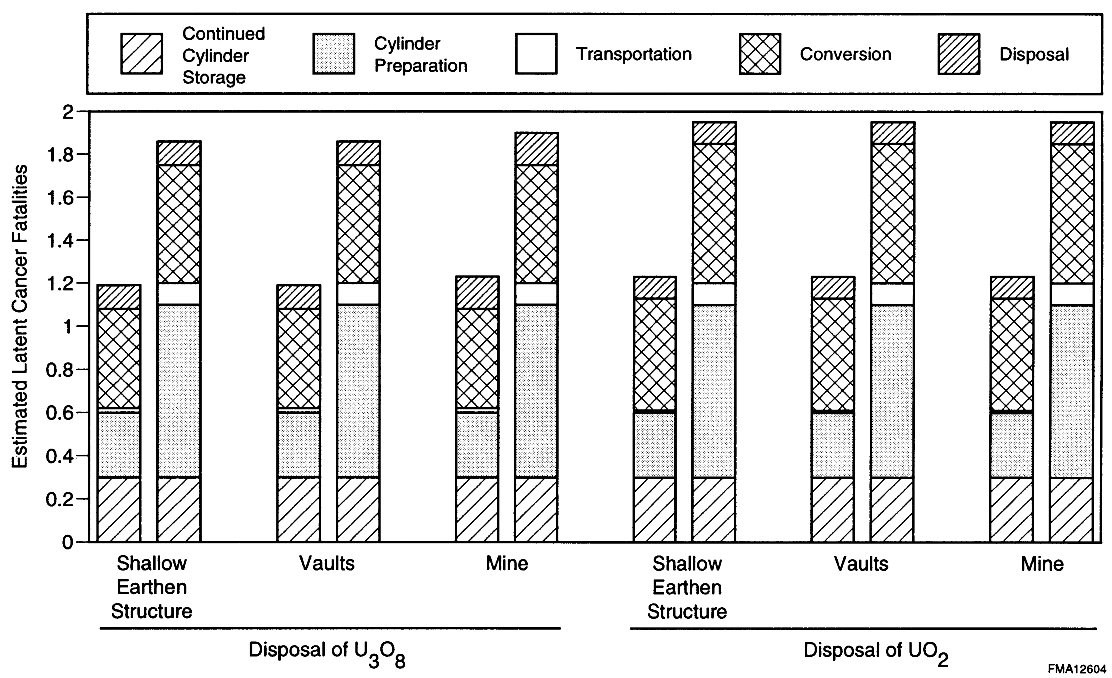

FIGURE 5.5 Total Estimated Number of LCFs among Involved Workers from Radiation Exposures during Normal Operations for the Disposal as Oxide Alternative, Assuming Ungrouted Waste, 1999 through 2039 (Note: The two bars presented for each option represent the minimum and maximum impacts estimated.)

Operational Phase. The potential impacts to members of the general public during the operational phase of the disposal as oxide alternative would be similar to the no action alternative — all exposures were estimated to be within applicable public health standards. No LCFs from radiation exposures and no adverse effects from chemical exposures were estimated to occur among members of the general public near the three current storage sites, near a conversion facility, or near a disposal facility from depleted UF_6 management activities.

At the current storage sites, potential impacts to members of the general public under the disposal as uranium oxide alternative would be exactly the same as described in Section 5.2.1.1.2 for the long-term storage as UF_6 alternative. In addition, impacts to members of the general public in the vicinity of an oxide conversion facility would be the same as those described for the long-term storage as oxide alternative in Section 5.3.1.1.2.

At a disposal facility, potential exposure of members of the general public to radiation or chemicals was estimated to be much less than at a conversion facility. During the disposal of ungrouted oxide, the drums would be disposed of without being reopened at the disposal facility; therefore, no releases would be expected during normal operations, and no off-site impacts to members of the general public would occur. Small airborne releases of uranium (through process filters) would occur if the oxide were grouted because the drums would be opened and the oxide mixed with cement prior to disposal. The total radiation dose to the general public (1999 through 2039) in the vicinity of a disposal site from airborne releases was estimated to be about 0.2 person-rem, resulting in zero LCFs. The maximum radiation dose to an individual near a disposal site was estimated to be about 0.05 mrem/yr from airborne emissions, well within applicable health standards (40 CFR Part 61; DOE Order 5400.5). No noncancer health effects from chemical exposures would be expected — the estimated hazard index for an individual near a disposal site was estimated to be less than 0.0002.

Post-Closure Phase (Long-Term Impacts). Potential impacts to members of the general public near the disposal site would be possible in the future if the groundwater became contaminated or if a person inadvertently intruded on the disposal facility. The extent of possible groundwater contamination would depend on the location and characteristics of the disposal site, such as the annual rainfall rate, the depth to the groundwater, and soil properties, as well as on the design of the disposal facility. Because of site selection and design considerations, groundwater contamination would not be expected to occur until hundreds to thousands of years after the disposal facility had been closed.

The potential effects on human health in the future were estimated by assuming that a person lived at the edge of the disposal site and used groundwater for drinking, irrigating plant foods and fodder, and feeding livestock. In addition, it was assumed that, at some point in the future, the engineered barriers of the disposal facility would fail, allowing uranium to be released into the soil. To address uncertainties related to the disposal site properties, the facility was assumed to be located at either a dry setting (typical of the western United States) or a wet setting (typical of the eastern

United States). In addition, it was assumed that the site had soil properties that permitted uranium to either move rapidly through the soil (mobile situation) or slowly through the soil (immobile situation). The potential radiation doses from future groundwater contamination were based on the estimated groundwater concentrations discussed in Section 5.6.4.2 and Appendix I, Section I.4.

In a dry setting, the groundwater analysis indicated that measurable groundwater contamination would not occur until more than 1,000 years after failure of the disposal facility, even if the uranium were assumed to move rapidly through the soil. Groundwater contamination would not occur within 1,000 years because of the small amount of rainfall typical of a dry setting and the resulting small amount of water that would infiltrate the disposal facility. In addition, a large distance to the groundwater table would be expected in a dry environment. Therefore, no radiation or chemical exposures of members of the general public from contaminated groundwater would be expected within 1,000 years following failure of a disposal facility in a dry environment.

In a typical wet setting, groundwater contamination was estimated to occur within 1,000 years after failure of the disposal facility for shallow earthen structures, vaults, and mines. The maximum radiation dose to an individual assumed to use contaminated groundwater was estimated to be about 100 mrem/yr if the soil properties were such that the uranium moved rapidly through the soil. If the depleted uranium was classified as LLW, the radiation doses from using contaminated groundwater would exceed the dose limit of 25 mrem/yr specified in 10 CFR Part 61 and DOE Order 5820.2A. In addition, the groundwater concentrations would be great enough to cause potential adverse effects from chemical exposures. The chemical hazard indices were calculated to range up to 10, indicating the potential for chemically induced adverse effects. However, impacts from using contaminated groundwater could be reduced or eliminated by treating the water or by using an alternative source of water.

In addition to possible exposures resulting from the use of contaminated groundwater, health impacts could result if a person inadvertently intruded or if the cover material (i.e., soil) above the disposal facility eroded away. The radiation dose was estimated to be as high as 10 rem/yr for a hypothetical future resident living on the disposal site in such a case (see Appendix I, Section I.4). Chemical health effects from uranium exposure could also be possible. Erosion of the cover material would probably not occur until several thousands of years after closure of a shallow earthen structure or vault disposal facility and would probably not occur at all for a mine disposal facility. If cover materials were to erode away, radiation exposures could be easily mitigated by adding new cover material. These considerations would be addressed in more detail during disposal facility design, site selection, licensing activities, and Phase II analyses and NEPA reviews if disposal were selected as the preferred alternative.

5.6.1.2 Facility Accidents

5.6.1.2.1 Physical Hazards (On-the-Job Injuries and Fatalities)

Accidents occur in all work environments. In 1994, about 5,000 work-related fatalities and 3.5 million work-related injuries were reported in the United States (National Safety Council 1995). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured during the disposal as oxide alternative, unrelated to any radiation or chemical exposures.

The number of accidental worker injuries and fatalities that might occur from 1999 through 2039 were estimated on the basis of the number of workers required over this period and the historical accident fatality and injury rates in similar types of industries. The estimated number of worker fatalities and injuries would be greater for the disposal as oxide alternative than the no action alternative because of the additional construction and operational activities required for cylinder preparation, conversion, and disposal facilities. The number of fatalities and injuries would depend on the specific cylinder preparation, conversion, and disposal options selected.

Considering all options, a range of 1 to 3 accidental worker fatalities from construction and operation of facilities were estimated over the 41-year period. The estimated number of accidental injuries (defined as injuries resulting in lost workdays) are shown in Figure 5.6. Approximately 700 to 1,800 injuries were estimated from construction and operation of facilities over the same period. At the current storage sites, the maximum total number of injuries was estimated to be about 700, assuming a cylinder transfer facility would be constructed and operated at each site. If cylinder overcontainers were used as the cylinder preparation option, a maximum of about 150 worker injuries were estimated at the three sites combined. Approximately 660 worker injuries were estimated to occur at a conversion facility (including treatment of empty cylinders), and approximately 100 to 450 worker injuries were estimated to occur at a disposal facility. These rates would not be unique to the activities required for the alternative, but would be typical of any industrial project of similar size and scope.

5.6.1.2.2 Accidents Involving Releases of Radiation or Chemicals

Under the disposal as oxide alternative, accidents potentially releasing radiation and chemicals could occur at the three current storage sites (during continued cylinder storage through 2028), at an oxide conversion site, and at a disposal site. For each site, a range of accidents was evaluated, from those considered reasonably likely to occur (once or more in 100 years on average) to those that would be extremely rare (expected to occur less than once in 1 million years on average). The accidents considered are described in Appendix D, Section D.2.2, for continued cylinder storage; Appendix F, Section F.3.2, for conversion; and Appendix I, Section I.3.2, for disposal.

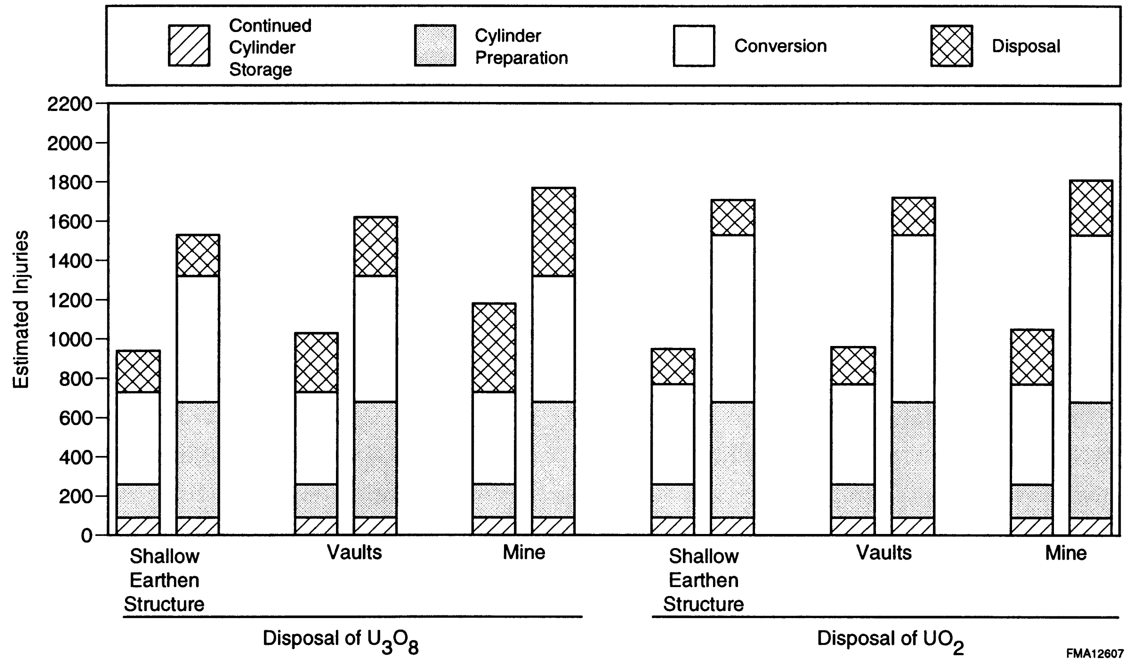

FIGURE 5.6 Total Estimated Number of On-the-Job Injuries (defined as injuries resulting in lost workdays) among All Workers from Construction and Operation of Facilities for the Disposal as Oxide Alternative, 1999 through 2039 (The two bars for each option represent the minimum and maximum impacts estimated.)

The potential consequences of cylinder accidents at the current storage sites and accidents at an oxide conversion facility are described in Section 5.1.1.2.2 for the no action alternative and in Section 5.3.1.2.2 for the long-term storage as oxide alternative. At a disposal facility, the potential consequences of all the accidents considered were estimated to be much less than potential conversion or cylinder accidents (see Appendix I). The disposal facility accident estimated to have the highest potential consequences was an earthquake accident during grouting operations that would release uranium oxide. This accident is considered unlikely. If such an accident occurred, potential chemical exposures of members of the general public were estimated to be much less than levels expected to cause adverse effects. Among noninvolved workers, up to 1 worker could experience adverse effects (mostly mild and transient effects) from chemical exposure to uranium, with no fatalities expected. This accident could also result in radiation exposures of workers and members of the general public. Among noninvolved workers, zero LCFs were estimated to be caused by radiation exposure if the accident did occur. Similarly, among members of the general public, zero radiation-induced LCFs were estimated if the accident occurred. The dose to any member of the general public was estimated to be considerably below the 25-rem dose recommended by the NRC (1994a) for assessing the adequacy of protection of public health and safety from potential accidents.

5.6.2 Transportation

The major materials assumed to be transported under the disposal as oxide alternative are summarized in Table 5.9. The transportation activities assumed to be required for the disposal as oxide alternative are the same as those described for long-term storage as oxide alternative in Section 5.3.2. The two alternatives differ only in the destination of the uranium oxide after conversion: it would either be shipped to a long-term storage facility or to a disposal facility. Because the locations of future storage or disposal sites will be evaluated in Phase II studies and NEPA reviews, in both cases the potential impacts from these shipments were estimated assuming a representative route of 620 miles (1,000 km). Therefore, the estimated impacts are the same for the two alternatives.

TABLE 5.9 Summary of the Major Materials Assumed to Be Transported, Estimated Number of Shipments, and Estimated Number of Traffic Accident Fatalities under the Disposal as Oxide Alternative, 1999 through 2039[a]

			Approximate Total Number of Shipments[b]		Estimated Traffic Accident Fatalities[c]	
Material	Origin	Destination	Truck	Rail	Truck	Rail
UF_6 cylinders	Current storage sites	Conversion site	46,422	11,600[d]	2	1
Uranium oxide (U_3O_8 or UO_2)	Conversion site	Disposal site	25,500 – 26,800	8,480 – 8,960	1	1
Ammonia	Supplier	Conversion site	520 (U_3O_8 conversion)	960 – 1,120 (UO_2 conversion)	0	0
Anhydrous HF (if produced)	Conversion site	User	–	4,860	0	0
CaF_2 (if HF neutralized)	Conversion site	User or disposal site	19,800	7,300	1	0
LLW/LLMW	Current storage/ conversion sites	Treatment/disposal site	900 – 2,360	–	0	0

[a] All materials were assumed to be transported to provide a conservative estimate of transportation impacts. A hyphen (–) denotes mode not considered for that material. Colocation of facilities would reduce transportation requirements.

[b] Estimated number of shipments assuming that either the truck or rail mode was used.

[c] Number of estimated traffic accident fatalities assuming each shipment traveled 620 miles (1,000 km) and using national average accident statistics. Estimates have been rounded to the nearest whole number.

[d] Number of railcars, each containing four cylinders.

In summary, it was assumed that cylinders would be transported from the current storage sites to an oxide conversion facility and the uranium oxide would be transported to a disposal facility (rather than a long-term storage facility). Process chemicals (ammonia), products of conversion (anhydrous HF or CaF_2), and any waste generated was also assumed to be transported. The impacts of these shipments during both normal and accident conditions are described in detail in Section 5.3.2.

5.6.3 Air Quality

The analysis of potential impacts on air quality for the disposal alternative considered the potential for air pollutant emissions from continued cylinder storage through 2028, cylinder preparation activities, conversion, and disposal activities. For continued cylinder storage and cylinder preparation activities at the current sites, impacts for the disposal as oxide alternative would be the same as those discussed for the long-term storage as UF_6 alternative (Section 5.2.3). For conversion to oxide, air quality impacts would be the same as discussed for the long-term storage as oxide alternative (Section 5.3). Air quality impacts from construction and operation of a disposal facility would depend on the actual facility location. Based on analyses for a generic setting of typical size for this type of facility, the concentrations of criteria pollutants were estimated to be within applicable standards. The criteria pollutant with the highest potential emissions would be NO_x; concentrations of NO_x were estimated to be within standards and guidelines, even when combining the effects of construction and operational activities which would be conducted simultaneously.

For disposal options that include grouting the waste, operation of a waste form facility would emit about 0.6 lb/yr (0.3 kg/yr) or 1.1 lb/yr (0.5 kg/yr) of uranium for grouted U_3O_8 and grouted UO_2 options, respectively. No air quality standards exist for uranium compounds; however, potential health impacts of these emissions were evaluated in Section 5.3.1.1.

5.6.4 Water and Soil

Water use for continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.4. At a conversion facility, water use would be the same as discussed in Section 5.3.4. For disposal, construction and operations would be occurring concurrently over the 20-year disposal period. Water use for construction would range from 0.2 to 2.8 million gal/yr; water use for operations would range from 0.1 to 20 million gal/yr. The upper ends of the ranges correspond to options for disposing of grouted wasteforms because the grouting operations would require larger amounts of water. Wastewater generation would range from about 0.1 to 0.2 million gal/yr for construction and from 0.1 to 1.3 million gal/yr for operations.

5.6.4.1 Surface Water

Under the disposal alternative, potential impacts on surface water at the current storage sites during continued storage of the cylinders and cylinder preparation would be the same as discussed for storage as UF_6 (Section 5.2.4.1). At a conversion facility, potential impacts to surface water would be the same as discussed for the long-term storage as oxide alternative (Section 5.3.4.1). At a disposal site, water use and wastewater generation would be approximately half or less than that required for a conversion facility. Impacts to surface water would depend on the actual location of the facility.

5.6.4.2 Groundwater

5.6.4.2.1 Operational Phase

Potential impacts on groundwater quality at the current storage sites from continued cylinder storage and cylinder preparation activities would be the same as discussed in Section 5.2.4.2. At a conversion facility, the potential impacts would be the same as discussed in Section 5.3.4.2. Potential groundwater impacts at a disposal facility would depend on the size of the site in comparison with the facility, on the proximity of the site to a river with fairly large flow volume (i.e., large in comparison with annual water use and wastewater discharge), and on whether the disposal facility water would be drawn from a surface water source or from groundwater. Because discharges to groundwater are not planned for these facilities, there would be no direct impacts on groundwater quality. Good engineering and construction practices would be followed to minimize the potential for adverse impacts during construction.

5.6.4.2.2 Post-Closure Phase (Long-Term Impacts)

For disposal, impacts on groundwater in the distant future would depend on the location of the facility. If the disposal facility were located in a dry environment typical of the western United States, groundwater impacts in the form of elevated uranium concentrations (i.e., concentrations greater than the proposed drinking water standard of 20 µg/L) would not occur for at least 1,000 years after failure of the facility. However, for a disposal facility in a wet environment, typical of the eastern United States, groundwater quality could be affected by contamination migrating from the disposal facility within 1,000 years after failure of the engineered barriers.

For purposes of analysis, if no sustained effort was made to maintain a disposal facility, failure of the facility (defined as the release of uranium material to the surrounding soil) was assumed to occur 100 years after closure (see Appendix I). This failure could be caused by natural degradation of the disposal structures over time, primarily from physical processes such as the intrusion of water. With good engineering, disposal facilities would actually be unlikely to fail for several hundred years or more.

Following failure, the release of uranium from the facility would occur very slowly as water moved through the disposed material. The amount of groundwater contamination, as well as the length of time it would take for the groundwater to become contaminated, would depend on the integrity of the drums and the engineered barriers, whether or not the waste was grouted, and site-specific properties of the soil surrounding the disposal facility. Without more precise information concerning the expected duration of effectiveness for the containers and engineered barriers in the specific disposal facility environment, as well as site-specific soil and hydrological properties, the potential groundwater concentrations are subject to a large degree of uncertainty.

For a generic wet setting, if the soil properties were such that the uranium moved relatively rapidly through the soil, the uranium concentration in the groundwater beneath the facility 1,000 years after facility failure was estimated to range from about 230 to 425 pCi/L (910 to 1,700 µg/L) for disposal of U_3O_8 and from about 190 to 320 pCi/L (760 to 1,300 µg/L) for disposal of UO_2. These uranium concentrations would exceed the guideline of 20 µg/L used for comparison. If the uranium moved less rapidly through the soil surrounding the disposal facility, uranium concentrations in the groundwater beneath the facility after 1,000 years could be much less than the guideline value. However, the concentrations would increase with time, ultimately approaching the concentrations discussed for the mobile situation, and exceeding the guideline.

For both U_3O_8 and UO_2, larger groundwater concentrations were estimated over the long term for disposal of grouted waste compared with ungrouted waste because grouting would increase the waste volume, essentially exposing a larger cross section of material to infiltrating water. However, further studies using site-specific soil characteristics would be necessary to determine the effect of grouting on long-term waste mobility. Grouting might reduce the dissolution of the waste and subsequent leaching of uranium into the groundwater in the first several hundred years after failure. However, over longer periods, the grouted form would be expected to deteriorate and, because of the long half-life of uranium, the performance of grouted and ungrouted waste would be essentially the same. Depending on soil properties, it is also possible that grouting could increase the solubility of the uranium material, resulting in more rapid groundwater contamination.

The potential impacts on groundwater would be essentially similar for disposal in shallow earthen structures, vaults, and or a mine because of the long time periods considered and the fact that the calculations were performed for 1,000 years after each facility was assumed to fail. However, shallow earthen structures would be expected to contain the waste material for a period of several hundred years before failure, and vaults and a mine would be expected to last even longer. Therefore, vault and mine disposal would provide greater protection in a wet environment. In addition, a vault or a mine would be expected to provide additional protection against erosion of the cover material (and possible exposure of the waste material) compared with shallow earthen structures. The exact time that any disposal facility would perform as designed would depend on the specific facility design and site characteristics.

5.6.4.3 Soil

Potential impacts on soil at the current storage sites and at a conversion site would be the same as discussed in Sections 5.2.4.3 and 5.3.4.3, respectively. Impacts at a disposal facility would depend on the actual location. Potential impacts, which would tend to be temporary, would generally result from the material excavated during construction that would be left on-site. The largest potential impacts on soil would occur from excavation for disposal. Construction for disposal could require excavating from about 300,000 to 2.6 million yd^3 (230,000 to 2.0 million m^3) of consolidated material. In the short term, this amount of material would cause changes in site topography. In the long term, contouring and reseeding would return the soil to its former condition, and the impacts would be minor. If a previously existing mine were used for disposal, excavation requirements could be significantly reduced, and potential impacts on soil would be much less.

5.6.5 Socioeconomics

Potential socioeconomic impacts associated with continued cylinder storage through 2028 and with cylinder preparation activities are discussed in Section 5.2.5. Socioeconomic impacts for an oxide conversion facility are summarized in Section 5.3.5. The potential socioeconomic impacts of construction and operation of a disposal facility (including the waste form facility) would depend on the facility location, facility type (i.e., shallow earthen structure, vault, or mine), and whether grouted or ungrouted oxide was disposed of. Construction would create from 65 to 770 direct jobs and from $3.5 to $42 million in direct income during the peak year of construction. Operation of the disposal facility would create from 60 to 180 direct jobs and produce from $6 to $18 million in direct income in each year of facility operation. For disposal, construction and operations would be occurring concurrently over the 20-year disposal period.

5.6.6 Ecology

5.6.6.1 Operational Phase

Potential impacts to ecological resources from continued storage through 2028 at the current storage sites are discussed in Section 5.2.6. Depending on the types of facilities, construction would disturb about 30 to 40 acres (12 to 16 ha) for conversion, 46 to 470 acres (18 to 190 ha) for disposal as U_3O_8, and 30 to 150 acres (12 to 61 ha) for disposal as UO_2. Existing vegetation at a conversion or disposal site would be destroyed during land-clearing activities. In addition, wildlife would be disturbed by land clearing, noise, and human presence. The extent of the impacts on ecological resources would depend on the locations of the facilities; in general, losses of 40 and 470 acres would constitute potential moderate and potential large adverse impacts in terms of habitat loss, respectively. Impacts to wetlands and state and federally protected species due to facility construction would also depend on the facility locations. Avoidance of wetland areas would be included during facility planning, and site-specific surveys for protected species would be conducted prior to finalization of facility siting plans.

Facility and transportation accidents, as discussed in Sections 5.6.1 and 5.6.2, could also 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 accident, season, and meteorological conditions.

5.6.6.2 Post-Closure Phase (Long-Term Impacts)

Potential impacts to aquatic biota could occur in the future if the disposal facility were to fail. Failure of facility integrity could result in contamination of groundwater at a wet setting within 1,000 years, as described in Section 5.6.4.2. Groundwater could discharge to the surface (such as in wetland areas) near the facility, thus exposing biota to contaminants. Groundwater concentrations of uranium calculated for 1,000 years after facility failure would range up to about 425 pCi/L. Adverse impacts to aquatic biota could result from exposure to soluble uranium compounds within this concentration range, although the resulting dose rates to maximally exposed organisms would be less than 0.015 rad/d, less than 2% of the dose limit of 1 rad/d for aquatic organisms, as specified in DOE Order 5400.5. These potential ecological impacts, which correspond to the groundwater concentration estimated for 1,000 years after failure of the disposal facility, are highly uncertain and would depend on site-specific characteristics and on whether aquatic biota would actually contact contaminants.

5.6.7 Waste Management

The waste management impacts of continued cylinder storage and cylinder preparation at the current sites are discussed in Section 5.2.7; waste management impacts of conversion at representative settings are discussed in Section 5.3.7. The maximum disposal volume of material would result from the disposal of grouted U_3O_8, approximately 312,000 m^3 over the duration of the program. This amount would represent approximately 7% of the projected DOE complexwide LLW disposal volume over the same approximate period (see Appendix C, Section C.10). If the U_3O_8 were not grouted, about 150,000 m^3 would be disposed of, representing about 3.5% of the projected DOE disposal volume. The volume of UO_2 disposed of would be approximately 72,000 m^3 if grouted and

48,000 m^3 if ungrouted, representing less than 2% of the projected DOE disposal volume in either case. Although these amounts of waste would be appreciable, it is expected that disposal would have only a low impact on DOE's total LLW disposal capabilities.

5.6.8 Resource Requirements

Resource requirements for continued cylinder storage, cylinder preparation, and conversion to oxide are discussed in Section 5.3.8. Construction and operation of facilities under the disposal alternative would consume electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals that are generally irretrievable resources. Specialty materials would not be required for construction of disposal facilities. In general, facility operational requirements are not resource intensive and the resources required are not considered rare or unique. However, for disposal in a mine, large quantities of electrical energy would be required during construction (up to 1,100 MW-yr) because the majority of the construction equipment required to build the underground portion would be powered by electricity. The impact of this high electrical requirement on local energy resource use would depend on the location of the facility and the existing infrastructure. If a previously existing mine were used for disposal, excavation and construction requirements would probably be reduced, depending on the characteristics and condition of the mine, and the electrical requirements would be subsequently reduced.

5.6.9 Land Use

Land-use impacts at the current cylinder storage sites from continued storage and cylinder preparation activities are discussed in Section 5.2.9. Impacts on land use for conversion and disposal would depend on the locations of the facilities. The amount of land required would range from about 30 to 40 acres (12 to 16 ha) for conversion, 46 to 470 acres (18 to 190 ha) for disposal of U_3O_8, and 30 to 150 acres (12 to 61 ha) for disposal of UO_2, constituting potential impacts to land use ranging from negligible to large. The large range for disposal results from two factors: (1) differences in the amounts of land required for shallow earthen structures, vaults, and mine disposal facilities; and (2) differences caused by whether the material is grouted (mixed with cement) or ungrouted prior to disposal. Grouting of the oxide would approximately double the amount of land required for disposal because the volume requiring disposal would increase. The smallest amount of land required for disposal would be for disposal of ungrouted UO_2 in shallow earthen structures, with the largest amount of land required for disposal of grouted U_3O_8 in a mine. For disposal in a mine, on-site topographical modifications associated with the disposition of excavated material could potentially affect future on-site land use. The potential for such impacts would be evaluated in site-specific NEPA documentation. Potential impacts to land use outside the boundaries of facilities would consist of temporary traffic impacts associated with project construction.

5.6.10 Cultural Resources

Potential impacts to cultural resources from continued cylinder storage and cylinder preparation activities at the three existing sites are discussed in Section 5.2.10. The impacts to cultural resources for conversion and disposal facilities would depend on specific locations of the facilities. Impacts to cultural resources would be evaluated in Phase II studies and avoided if necessary.

5.6.11 Environmental Justice

Potential environmental justice issues related to continued cylinder storage and cylinder preparation activities at the current storage sites would be the same as discussed in Section 5.2.11 for the long-term storage as UF_6 alternative. Potential environmental justice impacts to minority and low-income populations from the construction and operation of conversion and disposal facilities would depend on the locations of these facilities. Moreover, because transportation routes are not currently known, and because it is impossible to reliably predict who would be involved in transportation accidents, there is no reason to believe that the impacts of transportation accidents will affect minority or low-income populations disproportionately.

5.7 PREFERRED ALTERNATIVE

DOE's preferred alternative is to begin conversion of the depleted UF_6 inventory as soon as possible, either to uranium oxide, uranium metal, or a combination of both, while allowing for use of as much of this inventory as possible. The impacts of alternative strategies that would involve 100% use as oxide or 100% use as metal were analyzed and presented in Sections 5.4 and 5.5, respectively. Under the preferred alternative, conversion to oxide for use or long-term storage would begin as soon as practicable, with conversion to metal occurring only if uses are identified. The percentage of the depleted UF_6 inventory that would be used as oxide or converted and used as metal could vary. Additionally, most of the inventory would likely require interim storage as depleted uranium oxide pending use. Therefore, the impacts of the preferred alternative could involve a combination of the alternatives evaluated in the PEIS. To represent the impacts of a combination of use as oxide, use as metal, and storage as oxide, a strategy involving 25% use as oxide, 25% use as metal, and 50% long-term storage as oxide (henceforth called the combination strategy) was also analyzed and is discussed in this section. DOE has no preference regarding the actual percentages of the inventory that would be used as oxide or as metal; the 25% values used in this analysis were chosen for purposes of analysis.

In this PEIS, the use as oxide alternative assumed that UO_2 oxide would be used as radiation shielding in storage casks for spent nuclear fuel or HLW. However, current technology research and development on the use of uranium oxide as shielding material shows that the U_3O_8 oxide form could also be used, although somewhat less efficiently because of its lower density. In the analyses of potential impacts of the combination strategy presented in the following sections (Sections 5.7.1 through 5.7.11), the impacts for the conversion to oxide alternative and long-term storage as oxide alternative are therefore given as a range of impacts for either U_3O_8 or UO_2. The impacts from the manufacture and use as oxide were calculated and are presented for the UO_2 form only; these impacts are considered to be representative of impacts for manufacture and use as oxide in general.

The impacts of the combination strategy would include impacts during continued cylinder storage; preparation of cylinders for shipment; conversion of UF_6 to uranium oxide (U_3O_8 or UO_2) and metal; treatment of empty cylinders; manufacture of uranium oxide and uranium metal casks; long-term storage of uranium oxide (U_3O_8 or UO_2); and transportation of cylinders, conversion products (oxide, metal, HF or CaF_2, ammonia, and waste), and casks. The potential impacts of this alternative were calculated by combining the impacts from each of the individual components, as appropriate. Certain impacts, such as the dose to an MEI, are not additive because the MEI at each site would be different, and the future facilities were assumed to be built at separate sites (except for the continued storage and cylinder preparation activities, which were both assumed to occur at the current storage sites; and the conversion and cylinder treatment activities, which would likely occur at the same site). The values for potential impacts estimated for the combination alternative (as discussed in the following sections) were obtained from Appendix D (Section D.4) for the continued cylinder storage component, Appendix E for the cylinder preparation component, and Appendix K (Sections K.1–K.6) for the other components.

5.7.1 Human Health and Safety — Normal Operations

5.7.1.1 Radiological Impacts

Involved Workers. The calculation of radiological impacts to involved workers is outlined below. The impacts are first presented for each of the individual components and then summed, as appropriate, to provide an estimate of the total radiological impact.

Continued Cylinder Storage. Potential radiological impacts during continued cylinder storage at the three current storage sites are the same as those previously estimated for the action alternatives (Section D.4.1.1); that is, 720 person-rem.

Cylinder Preparation. The total collective dose to involved workers would range from 835 person-rem for use of cylinder overcontainers for all cylinders from all three sites to 2,170 person-rem for transfer of all cylinders to new cylinders at the three sites (Section E. 3.1.1).

Conversion. The doses to workers from conversion for various throughput rates are provided in Figure K.5 for conversion to U_3O_8, Figure K.11 for conversion to UO_2, and in Figure K.17 for conversion to uranium metal. From these data, the estimated collective involved worker doses for conversion of 75% of the inventory to oxide and 25% to uranium metal are as follows:

Annual dose to workers from conversion of 75% of the inventory to U_3O_8
= 34 person-rem/yr

Total worker dose from conversion to U_3O_8 = 34 person–rem/yr
× 20 years = 680 person-rem

Annual dose to workers from conversion of 75% of the inventory to UO_2
= 40 to 46 person-rem/yr

Total worker dose from conversion to UO_2 = 40 to 46 person-rem/yr
× 20 years = 800 to 920 person-rem

Range for conversion of 75% of the inventory to oxide: 680–920 person-rem

Annual dose to workers from conversion of 25% of the inventory to metal
= 15 to 50 person-rem/yr

Total worker dose from conversion to metal = 5 to 50 person-rem/yr
× 20 years = 300 to 1,000 person-rem

Cylinder Treatment. The collective dose to workers from the treatment of empty cylinders for a range in the number of cylinders treated is provided in Figure K.23. It was assumed that two treatment facilities would be required, one for a 75%-capacity oxide conversion facility and one for a 25%-capacity metal conversion facility. On this basis, the estimated doses to workers are as follows:

Annual dose to workers from treatment of 75% of the cylinder inventory
= 13 person-rem/yr

Annual dose to workers from treatment of 25% of the cylinder inventory
= 7 person-rem/yr

Total worker dose from cylinder treatment = 13 + 7 person-rem/yr
× 20 years = 400 person-rem

Long-Term Storage. The doses to workers for long-term storage as oxide at various throughput rates are provided in Section K.3.1.1. From these data, the estimated collective involved worker doses for long-term storage of 50% of the inventory as oxide are as follows:

Annual dose to workers from long-term storage of 50% of the inventory as U_3O_8
= 15 person-rem/yr (from Figure K.33)

Annual dose to workers from long-term storage of 50% of the inventory as UO_2
= 9 person-rem/yr (from Figure K.31)

Range for long-term storage of 50% of the inventory as oxide
= 9 to 15 person-rem/yr × 31 years = 280 to 465 person-rem

Manufacture and Use. The doses to workers from manufacture and use for various throughput rates are provided in Figure K.41 for manufacture of UO_2-shielded casks and in Figure K.47 for manufacture of uranium metal-shielded casks. From these data, the estimated worker doses for manufacture of 25% of the inventory to oxide shielded casks and 25% to metal-shielded casks are as follows:

Annual dose to workers from manufacture of 25% of the inventory to UO_2 casks
= 10 person-rem/yr

Total worker dose from manufacture of UO_2 casks
= 10 person-rem/yr × 20 years = 200 person-rem

Annual dose to workers from manufacture of 25% of the inventory to metal casks
= 2 person-rem/yr

Total worker dose from manufacture of metal casks
= 2 person-rem/yr × 20 years = 40 person-rem

Total Radiological Impacts to Workers. The total collective radiation dose to involved workers was calculated by summing the collective doses from the individual components. The individual contributions, as well as the total dose, are summarized in Table 5.10. In addition, the number of radiation-induced health effects was estimated by multiplying the collective dose by a health risk conversion factor of 4×10^{-4} LCF/person-rem for involved workers. The total LCFs among workers were estimated to range from one to two over the duration of the program. Similar to the 100% use as oxide, 100% use as metal, and 100% long-term storage as oxide alternatives, the radiological impacts to noninvolved workers were estimated to be negligible compared with those to involved workers.

TABLE 5.10 Range of Radiological Doses and Latent Cancer Fatalities among Involved Workers for the 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage Combination Strategy[a]

Component	Collective Dose (person-rem)
Continued cylinder storage	720
Cylinder preparation	840 – 2,200
Oxide conversion	680 – 920
Metal conversion	300 – 1,000
Cylinder treatment	400
Long-term storage	280 – 470
Manufacture of oxide casks	200
Manufacture of metal casks	40
Total dose	3,500 – 6,000
Latent cancer fatalities[b]	1 – 2

[a] Values rounded to 2 significant figures.

[b] The number of latent cancer fatalities was calculated using a health risk conversion factor of 4×10^{-4} LCF/person-rem for workers. Values rounded to one significant figure.

General Public. The collective radiation dose to members of the general public was calculated in a manner similar to that outlined above for involved workers, as follows:

Collective dose to public from continued cylinder storage (Table D.1)
= 1.1 person-rem

Collective dose to public from cylinder preparation (Tables E.1, E.2, and E.3)
= 0 to 0.006 person-rem

Collective dose to public from conversion to oxide (Figures K.1 and K.7)
= 0.6 to 9 person-rem

Collective dose to public from conversion to metal (Figure K.13)
= 0 to 3 person-rem

Collective dose to public from cylinder treatment (Figure K.19)
= 0.007 person-rem

Collective dose to public from long-term storage (Section K.3.1.2)
= approximately 0 because emissions are negligible

Collective dose to public from manufacture of oxide casks (Figure K.37)
= 0 to 0.02 person-rem

Collective dose to public from manufacture of metal casks (Figure K.43)
= 0.01 to 0.4 person-rem

The total collective dose to the public is estimated to range from approximately 1.8 to 14 person-rem. This dose would most likely result in no additional latent cancer fatalities among the public.

Because continued storage, conversion, long-term storage and manufacturing activities were assumed to occur at separate sites and the results of the parametric analyses indicate that impacts to individuals among the public would decrease with a decrease in the amount processed, the dose to general public MEIs from the combination strategy would be less than the estimates presented for the 100% use strategies in Sections 5.4 and 5.5. All doses to individual members of the general public would be well below applicable standards and regulatory limits.

5.7.1.2 Chemical Impacts

Chemical impacts to noninvolved workers and the general public from components constituting the combination strategy are generally nonadditive because these impacts were estimated for MEIs at each site and future facilities were assumed to be built at separate sites. The two exceptions are (1) continued storage and cylinder preparation activities, which would take place at the current storage sites; and (2) conversion and cylinder treatment activities, which would likely occur at the same site.

Estimated hazard indexes for MEIs for all management options are much less than 1 (a hazard index of greater than 1 indicates the potential for health impacts). The maximum hazard index for noninvolved workers and the general public for long-term storage activities is approximately 0 (Table G.5), and for manufacturing activities, it is 6.7×10^{-6} (Table H.4). To provide a conservative estimate of potential hazards from activities that would occur at the same sites, the maximum hazard index for both workers and the general public from continued cylinder storage activities for 1999 through 2039 (0.065; Tables D.5 and D.25) was added to the maximum hazard index from cylinder preparation activities (6.1×10^{-6}; Section E.3.1.2). Similarly, the maximum hazard index from conversion options (1.5×10^{-4}; Table F.6) was added to the maximum hazard index from cylinder treatment (7.1×10^{-8}; Table F.6). The results in all cases are still much lower than 1, so adverse chemical impacts from normal operations would not be associated with this combination strategy.

5.7.2 Human Health and Safety — Accident Conditions

5.7.2.1 Radiological and Chemical Impacts

For the combination strategy, the bounding impacts from accidents involving radiological or chemical releases would be the larger of the impacts estimated for the long-term storage as oxide, use as oxide, and use as metal strategies. (See Sections 5.3.1.2, 5.4.1.2, and 5.5.1.2 for detailed discussions of the impacts of these accidents.) The consequences of bounding accidents for the combination strategy would be the same as the consequences of accidents under these use strategies because about the same amount of material would be at risk of being released under accident conditions, regardless of the facility size or throughput. Although the frequencies of some accidents (for example, cylinder-handling accidents) would decrease somewhat as the facility throughput decreased, the overall frequency category for those accidents would remain the same despite these small changes in frequencies.

5.7.2.2 Physical Hazards

Physical hazards to involved and noninvolved workers were estimated by summing the injury and fatality hazards from each of the components constituting the combination strategy, similar to the method described for estimating involved worker collective radiation dose in Section 5.7.1.1. For the combination strategy, the calculations to estimate physical hazards are outlined below.

Continued Cylinder Storage. The numbers of fatalities and injuries during continued cylinder storage at the three current storage sites are the same as those previously estimated for the action alternatives (Section D.4.2.3); that is, 0.07 fatality and 90 injuries.

Cylinder Preparation. The total number of fatalities and injuries for workers would range from 0.14 fatality and 187 injuries for use of cylinder overcontainers for all cylinders from all three sites, to 0.86 fatality and 630 injuries for transfer of cylinders to new cylinders at all three sites (Section E.3.2.3). These values are estimates of the total fatalities and injuries over the entire 20-year period that cylinder preparation activities were assumed to be ongoing.

Conversion. The estimated numbers of fatalities and injuries for conversion of various throughput rates are provided in Section K.2.2.3. The estimated numbers of fatalities and injuries from conversion for the combination strategy are as follows:

Fatalities among workers from conversion of 75% of the inventory to U_3O_8
= 0.33 fatality

Fatalities among workers from conversion of 75% of the inventory to UO_2
= 0.39 to 0.57 fatality

Range for conversion of 75% of the inventory to oxide
= 0.33 to 0.57 fatality

Injuries among workers from conversion of 75% of the inventory to U_3O_8
= 270 injuries
Injuries among workers from conversion of 75% of the inventory to UO_2
= 320 to 490 injuries

Range for conversion of 75% of the inventory to oxide
= 270 to 490 injuries

Fatalities among workers from conversion of 25% of the inventory to metal
= 0.33 to 0.49 fatality

Injuries among workers from conversion of 25% of the inventory to metal
= 280 to 450 injuries

Cylinder Treatment. The estimated numbers of fatalities and injuries from the treatment of empty cylinders for a range in the number of cylinders treated is provided in Section K.2.2.3. For the combination strategy, it was assumed that one 75%-capacity treatment facility and one 25%-capacity treatment facility would likely be constructed. The estimated numbers of fatalities and injuries from cylinder treatment are as follows:

Fatalities among workers from treatment of 75% of the cylinder inventory = 0.17 fatality

Fatalities among workers from treatment of 25% of the cylinder inventory = 0.13 fatality

Injuries among workers from treatment of 75% of the cylinder inventory = 150 injuries

Injuries among workers from treatment of 25% of the cylinder inventory = 120 injuries

Total fatalities = 0.30 fatality

Total injuries = 270 injuries

Long-Term Storage. The estimated numbers of fatalities and injuries for long-term storage at various throughput rates are provided in Section K.3.2.3. From these data, the estimated values for long-term storage of 50% of the inventory as oxide are as follows:

Fatalities among workers from long-term storage of 50% of the inventory as U_3O_8
= 0.17 to 0.36 fatality

Fatalities among workers from long-term storage of 50% of the inventory as UO_2
= 0.10 to 0.19 fatality

Range for storage of 50% of the inventory as oxide = 0.10 to 0.36 fatality

Injuries among workers from long-term storage of 50% of the inventory as U_3O_8
= 114 to 176 injuries

Injuries among workers from long-term storage of 50% of the inventory as UO_2
= 76 to 110 injuries

Range for storage of 50% of the inventory as oxide = 76 to 176 injuries

Manufacture and Use. Fatalities and injuries for manufacture of UO_2- or metal-shielded casks are presented in Section K.4.2.3. The estimated numbers of fatalities and injuries for the combination strategy are as follows:

Fatalities among workers from manufacture of 25% of the inventory to UO_2 casks
= 0.60 fatality

Injuries among workers from manufacture of 25% of the inventory to UO_2 casks
= 480 injuries

Fatalities among workers from manufacture of 25% of the inventory to metal casks
= 0.70 fatality

Injuries among workers from manufacture of 25% of the inventory to metal casks
= 510 injuries

Total Physical Hazards. The total fatalities and injuries were calculated by summing the values for the individual components. The individual contributions and total fatalities and injuries are summarized in Table 5.11.

TABLE 5.11 Range of On-the-Job Fatalities and Injuries among Workers for the 25% Use as Oxide, 25% Use as Metal, 50% Long-Term Storage Combination Strategy[a]

Component	Fatalities	Injuries
Continued cylinder storage	0.07	90
Cylinder preparation	0.14 – 0.86	190 - 630
Oxide conversion	0.33 – 0.57	270 – 490
Metal conversion	0.33 – 0.49	280 – 450
Long-term storage	0.1 – 0.36	80 – 180
Cylinder treatment	0.30	270
Manufacture of oxide casks	0.60	480
Manufacture of metal casks	0.70	510
Total	3 – 4	2,200 – 3,100

[a] Represents impacts to involved and noninvolved workers from construction and operation of facilities. Values rounded to two significant figures.

5.7.3 Transportation

The transportation impacts for normal operations and traffic accident fatalities were determined by the number of shipments required for the combination strategy, assuming a travel distance of 620 miles (1,000 km) per shipment. These impacts would be the sum of the number of shipments if 25% of the inventory were converted for use as oxide, 25% of the inventory were converted for use as metal, and 50% were converted to oxide for long-term storage. As for the 100% use as oxide and 100% use as metal strategies, the impacts for exposures from normal operations (i.e., vehicular exhaust inhalation) would be no more than one fatality expected among workers and members of the general public combined. About four traffic accident fatalities would be expected for the combination strategy, about the same as expected for the 100% use as oxide or metal strategies

For the combination strategy, the bounding impacts for accidents involving releases from cylinders or releases of other materials would be the larger of the impacts estimated for the long-term storage as oxide, use as oxide, or use as metal alternative strategies. The consequences would be the same as the consequences of these strategies because the same amount of material (i.e., a single shipment) would be at risk under accident conditions, regardless of the number of shipments. The combination strategy would require approximately the same number of shipments as these strategies, so the overall probability of accidents occurring under this strategy is about the same as that for the other strategies.

5.7.4 Air Quality

Air quality impacts from construction at the current storage sites would be the same as those predicted for the no action alternative because all construction activities are planned to take place prior to about 2003, during which time all cylinders would remain at the current storage locations under all alternatives examined, including the combination strategy. Impacts during operations at the current storage sites would be the same as those predicted under the 100% use as oxide strategy (because the rate of cylinder removal would be the same under the combination strategy).

Pollutant emissions during construction and operation of conversion, long-term storage, and manufacturing facilities designed to handle 25% to 75% of the inventory would remain within standards, and would be somewhat reduced for facilities with lower throughput rates.

5.7.5 Water and Soil

Similar to the situation for air quality impacts, groundwater impacts at the current storage sites for the combination strategy would be the same as those predicted for the 100% use as oxide strategy. Potential surface water, groundwater, and soil quality impacts at conversion, long-term storage, and manufacturing facilities would be site-dependent, but, on the basis of evaluation of representative and generic sites, contaminant concentrations would be expected to remain within guideline levels. The long-term storage component of the preferred alternative could require excavating between about 41,000 yd^3 to 1.1 million yd^3 of consolidated material.

5.7.6 Socioeconomics

5.7.6.1 Continued Cylinder Storage

Socioeconomic impacts from construction activities at the current storage sites would be the same as those predicted for the no action alternative because all construction activities are planned to take place prior to about 2003, during which time all cylinders would remain at the current storage locations under the combination strategy. Impacts during operations at the current storage sites would be the same as those predicted under the 100% use as oxide strategy (because the rate of cylinder removal would be the same under the combination strategy).

5.7.6.2 Cylinder Preparation, Conversion, Long-Term Storage, and Manufacturing

Parametric socioeconomic impacts for the cylinder preparation, conversion, long-term storage, and manufacturing options were assessed qualitatively in Sections E.3.5, K.2.5, K.3.5, and K.4.5 on the basis of the preliminary cost data for the 100% cases (LLNL 1996) and socioeconomic data for parametric cases provided in a cost analysis report (LLNL 1997b). For conversion activities, the maximum estimated direct jobs and direct income values for the combination strategy calculated using the above-described data are about 1.5 times greater than estimated for the 100% use as oxide and 100% use as metal strategies, respectively. Similarly, the maximum estimated direct jobs and income for manufacturing activities under the combination strategy are about 1.5 times greater than estimated for the 100% use strategies. These differences are mainly a result of the need to construct and operate two separate conversion facilities, two separate manufacturing facilities, and a separate long-term storage facility under the combination strategy.

5.7.7 Ecology

The principal differences in ecological impacts between the combination strategy and the 100% use strategies would be associated with habitat loss at conversion, long-term storage, and manufacturing facilities. Potential habitat loss at the current storage sites is the sum of habitat loss that would occur under the no action alternative (7 acres [2.8 ha]), which would be applicable for all alternatives because construction would occur prior to 2003, and loss that would occur from cylinder preparation activities. The use of overcontainers would avoid the loss of additional habitat. Transfer facilities would range in areal site requirements from about 12 acres (4.9 ha) for a facility to process the inventory at the K-25 site (10% of the entire inventory), to 14 acres (5.7 ha) for a facility to process the inventory at the Portsmouth site (30% of the entire inventory), to 21 acres (8.5 ha) for a facility to process the inventory at the Paducah site (60% of the entire inventory) (see Section E.3.6). For alternatives involving 100% use, the maximum habitat loss at any site would be 28 acres (21 + 7) (11 ha).

Potential habitat loss for conversion facilities was calculated on the basis of data provided in Section K.2.9. The habitat loss corresponding to a 75%-capacity U_3O_8 conversion facility would be about 18 acres (7.3 ha); the loss corresponding to a 75%-capacity UO_2 conversion facility would be about 22 acres (9.0 ha). The habitat loss corresponding to a 25% capacity metal conversion facility would be 17 acres (6.8 ha). For a 75%-capacity cylinder treatment facility, the habitat loss would be about 8 acres (3.3 ha); habitat loss for a 25%-capacity cylinder treatment facility would be about 7 acres (3 ha). Although these parametric values were calculated for specific conversion options (e.g., conversion to UO_2 by the dry process, with anhydrous HF production), the amount of land required for the other conversion technologies would be roughly similar. It was assumed that two cylinder treatment facilities would be required, one for each conversion facility. The total habitat loss for conversion for the combination strategy was therefore calculated as a maximum of from 26 to 30 acres for a 75%-capacity oxide conversion facility and about 24 acres for a separate 25%-capacity metal conversion facility (total of about 50 to 54 acres).

Potential habitat loss for long-term storage facilities was estimated from data provided in Section K.3.9. For a 50%-capacity storage as oxide facility, habitat loss would be approximately 49 acres (20 ha).

Potential habitat loss for manufacturing facilities was calculated on the basis of data given in Section K.4.9. For an oxide cask manufacturing facility, the land areas corresponding to a 25%-capacity facility would be 79 acres (32 ha); the land area for a 25%-capacity metal cask manufacturing facility would be the same. Therefore, the total habitat loss for manufacturing for the combination strategy would be about 79 acres at any single site (total of about 160 acres).

5.7.8 Waste Management

For waste management at the current storage sites, impacts for the combination strategy would be similar to those estimated for the 100% use as oxide and 100% use as metal strategies.

Conversion of 100% of the inventory to either oxide or metal could have potential moderate impacts to nationwide LLW generation on the basis of a possible requirement to dispose of CaF_2 and/or MgF_2 as LLW (see Sections 5.3.7 and 5.5.7). If such disposal were required and these wastes were considered DOE waste, these strategies could generate a volume of LLW equal to about 10% of the projected DOE complexwide disposal volume. Moderate impacts to nationwide waste management are defined as additional volumes in excess of 10% of the DOE complexwide disposal volume; negligible impacts generate less than 10%. Assuming a linear decrease in potential LLW production, the combination strategy involving 75% conversion to oxide and 25% conversion to metal could have low to moderate impacts on nationwide LLW management.

The potential waste management impacts for various throughput rates for long-term storage and manufacturing facilities are discussed in Sections K.3.7 and K.4.7, respectively. Since waste management impacts for the 100% throughput rates for these facilities are generally negligible, impacts would also be negligible for the lower throughput rates considered for the combination alternative.

5.7.9 Resource Requirements

Under the combination strategy, adverse effects on local, regional, or national availability of materials would not be expected.

5.7.10 Land Use

Land use corresponds to habitat loss. See Section 5.7.7 for an explanation of the values calculated for the combination strategy.

5.7.11 Other Areas of Impact

Impacts to cultural resources at the current storage sites would depend on the selected locations for construction activities but are considered unlikely because construction would occur on land previously developed. Impacts to cultural resources at other facilities would depend on the locations and will be examined in detail at the next stage of the program when facilities are actually sited. Adverse environmental justice impacts for activities occurring under the combination strategy are not expected. The occurrence of severe transportation accidents involving a release are unlikely, and accidents occur randomly along transportation corridors; therefore, significant and disproportionate high and adverse impacts to minority or low-income populations are unlikely.

5.8 CUMULATIVE IMPACTS

Cumulative impacts are those impacts that result from the incremental impact of an action (in this case, depleted UF_6 management) when added to the impacts of other past, present, and reasonably foreseeable future actions. To conduct the cumulative impacts analysis, DOE examined those impacts associated with depleted UF_6 management activities certain to occur at the three current depleted UF_6 storage sites (Paducah, Portsmouth, and K-25 sites under all alternatives), which includes continued cylinder storage for some period for all alternatives and cylinder preparation for shipment for all alternatives except the no action alternative. To these impacts, DOE then added the impacts of other past, present, and reasonably foreseeable future actions in order to assess cumulative impacts. The USEC actions related to enrichment activities are included as a continuation of past DOE actions at the Paducah and Portsmouth sites. Non-DOE actions are considered when they will occur at one of the three depleted UF_6 storage sites, or when the nature of their impacts at locations near the three sites could increase impacts anticipated at the sites themselves.

5.8.1 Cumulative Impact Issues and Assumptions

The cumulative impact analysis considered the following impact areas for existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions:

- ***Health Risk:***
  - Collective radiation dose and cancer risk for the general public over the 41-year period of depleted UF_6 operations,
  - Annual radiation dose for a hypothetical maximally exposed off-site individual,
  - Collective radiation dose and cancer risk for the worker population at a given site, and
  - Number of truck or rail shipments of radioactive materials to and from each site and the contributions to the dose to an MEI near the site gate;
- ***Environmental Quality:***
  - Potential emissions that affect air quality compared to air quality standards and
  - Potential contaminants that affect groundwater quality concentrations compared to drinking water standards or other guideline values;
- ***Resource and Infrastructure Requirements:***
  - Land requirements (presented as the percent of suitable land at each site occupied by existing facilities and needed for depleted UF_6 management activities and other future actions),
  - Percent of current water supply (presented as the percent of existing capacity needed for existing operations, depleted UF_6 management activities, and other future actions),
  - Percent of current wastewater treatment capacity (presented as the percent of existing capacity needed for existing operations, depleted UF_6 management activities, and other future actions), and

- Percent of current power capacity (presented as the percent of existing capacity needed for existing operations, depleted UF_6 management activities, and other future actions).

The health risks to the off-site population are reported as collective exposures and risks for the entire period of conducting a particular operation, while the dose to the maximally exposed individual is reported as an annual value. Annual exposures are used for the maximally exposed individual to allow a direct comparison to the DOE maximum dose limit of 100 mrem/yr exposure to an individual of the general public (MEI) from all radiation sources and exposure pathways (DOE Order 5400.5). A cumulative impacts table containing the impact categories and the major elements composing the cumulative impacts is presented for each of the three sites. These elements include the existing conditions at the site, the maximum impacts of depleted UF_6 management activities analyzed in this PEIS, and the impacts of other reasonably foreseeable future actions.

The impact categories addressed as part of the cumulative impact analysis for each of the sites are those associated with depleted UF_6 management that might generate noteworthy environmental effects when aggregated with the environmental consequences of other actions. Some impacts, such as impacts to ecological resources and cultural resources, were not included in the cumulative impact analysis because they are dependent on the specific facility location within the site boundary and location-specific environmental factors. Other impacts, such as impacts of accidents, were not included because it is highly improbable that accidents would occur together.

Cumulative impacts for the Paducah, Portsmouth, and K-25 sites were evaluated by adding the impacts of depleted UF_6 management options to the impacts of past, present, and reasonably foreseeable future actions at each site and in the region (primarily actions that DOE is considering for other programs). The latter include actions related to production and management of nuclear materials, management of nuclear fuel, research and development activities, and defense programs as described in various environmental assessments and EISs listed in Section 1.6. To assess the effects of cumulative impacts, the estimated cumulative impacts calculated for each site were compared to regulatory levels for MEI exposures, air quality standards, and drinking water standards or guidelines for these parameters. If regulatory levels or guidelines would be exceeded, then the impact could be considered significant. LCFs among the public would be considered significant if the cumulative impacts of activities at a site would yield more than 1 LCF over the 41-year period. Because radiological exposure of workers would be maintained at or below regulatory levels, resulting LCFs to those individuals would be those corresponding to acceptable radiation doses. Resources and infrastructure impacts would be considered significant if the land area required, water use, wastewater production, or power demand approached 100% of capacity for the site.

Cumulative impacts also included the consequences of recent and current environmental restoration actions. The impacts of future environmental restoration actions at the three sites were not included in the cumulative impact analysis because of insufficient characterization of the contamination and because proposals for particular actions are not yet final. Impacts of future environmental restoration activities at these sites would be analyzed in later site-specific CERCLA/RCRA program documents.

Past impacts included in the cumulative impact analysis consist of past construction, development, and environmental restoration activities that contributed to existing conditions at each site and any past activities that may have resulted in current groundwater contamination at each site; these are presented as impacts of existing operations. Although dose reconstruction studies were conducted at several DOE sites, including the Oak Ridge Reservation, these studies have not progressed to the point that would allow their incorporation in this PEIS.

No assumptions are made regarding future baseline conditions at each of the storage sites that could potentially reduce impacts, such as cessation of certain ongoing operations that would reduce current levels of radioactive releases. A number of other simplifying assumptions were made to estimate cumulative impacts regarding timing, site location, and consistency of analytical methods. Other existing or planned actions at each site were assumed to occur during the period of depleted UF_6 management operations. These other actions were assumed to be collocated with depleted UF_6 management facilities to the extent that they affect the same off-site population and MEI. These assumptions result in conservative analyses that overestimate actual cumulative impacts.

Some or most of the depleted UF_6 cylinder management activities currently occurring at the sites (and considered under existing operations) would persist during continued storage and are included in the impacts of continued storage. When estimating cumulative impacts over the 41-year assessment period, no adjustment was made for this overlap. This adds to the conservatism in the calculated cumulative collective population impacts for both the workers and members of the general public at each site.

The above simplifying assumptions could result in some differences in estimated impacts between the PEIS and site-specific documents. In addition, these simplifying assumptions and other assumptions used in performing calculations can result in some uncertainty regarding projected cumulative impacts. The cumulative impact analysis in the PEIS should be used only for evaluating the PEIS program; any site-specific analysis would supersede the PEIS cumulative analysis for that site.

5.8.2 Impacts of Continued Cylinder Storage and Preparation

This analysis focuses on potential cumulative impacts at the three sites where continued storage and cylinder preparation would occur — the Paducah, Portsmouth, and K-25 sites. For purposes of analysis, the maximum impacts estimated at each site for continued cylinder storage and cylinder preparation activities from any of the PEIS alternatives were used to provide an upper estimate of potential cumulative impacts. The three sites are discussed separately in Sections 5.8.2.1 through 5.8.2.3.

5.8.2.1 Paducah Site

Actions planned at the Paducah site include the continuation of uranium enrichment operations, waste management activities (including the Vortec vitrification system [DOE 1998b]), environmental restoration activities, and the depleted UF_6 management activities addressed in this PEIS. Actions occurring near the Paducah site that could contribute to the existing or future impacts on the site (because of their diffuse nature) include continued operation of the Tennessee Valley Authority's Shawnee power plant; the Joppa, Illinois, power plant (see DOE 1998b); and the Allied Signal uranium conversion plant in Metropolis, Illinois (NRC 1995). Table 5.12 identifies the projected cumulative impacts that could result from depleted UF_6 management activities and current activities at the Paducah site. As identified in the table, the maximum annual radioactive releases that would result from depleted UF_6 management would result in an increase in the dose to the off-site population. However, cumulative radioactive releases at the Paducah site would still be considerably below the maximum DOE dose limit of 100 mrem/yr to the off-site MEI.

The depleted UF_6 management options would be unlikely to result in additional land disturbance at Paducah because all activities are expected to occur on currently developed land. On-site infrastructure demands for water, wastewater treatment, and power would increase by at most very small amounts due to the depleted UF_6 management activities. Cumulative requirements would remain well within existing capacities.

The Paducah site is located in an attainment region where criteria air pollutants do not currently exceed regulatory standards. During construction activities at the site for continued storage or cylinder preparation, pollutant concentrations at the facility boundary would generally not exceed applicable air quality standards or guidelines. If short-term concentrations of fugitive dust emissions (PM_{10}) approached air quality standards during construction, these impacts would be temporary and could be minimized by good engineering and construction practices and standard dust suppression methods.

Data from 1996 annual groundwater monitoring showed 18 pollutants exceeding primary drinking water regulation levels in groundwater at the Paducah site: antimony, chromium, lead, nickel, nitrate, thallium, uranium, benzene, 1,2-dichloroethane, cis-1,2-dichloroethene, 1,1,-dichloroethene, ethyl benzene, tetrachloroethene, trichloroethylene, vinyl chloride, radon-222, radium-226, and technetium-99 (LMES 1997c). Fluoride has also exceeded its primary drinking water regulation level of 4 mg/L in two on-site wells (LMES 1996a).

TABLE 5.12 Cumulative Impacts of Depleted UF_6 Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at the Paducah Site, 1999 through 2039

Impact Category	Impacts of Existing Operations[a]	Maximum Impacts of Depleted UF_6 Management Activities: Continued Storage[b]	Maximum Impacts of Depleted UF_6 Management Activities: Cylinder Preparation	Impacts of Other Reasonably Foreseeable Future Actions[c]	Cumulative Impacts[d]
Off-site population					
Collective dose, 41 years (person-rem)	4.8	0.34	0.0030	24.6	29.7
Number of LCFs[e]	0.002	0.0002	1.5×10^{-6}	1.2×10^{-2}	0.02
Annual dose to off-site MEI[f] (mrem)	3.03	0.10	2.0×10^{-5}	1.5	4.6
Worker population					
Collective dose, 41 years (person-rem)	213	900	1,000	4.1	2,117
Number of LCFs[g]	0.09	0.37	0.40	0.0016	0.85
Transportation[h]					
Number of truck shipments, 41 years	40,836	–	28,513	6,330	75,679
Number of rail shipments, 41 years	0	–	7,129	2,410	9,539
Annual dose to MEI from truck (mrem)	3.98	–	0.0077	0.010	4.0
Annual dose to MEI from rail (mrem)	0.0	–	0.0053	0.0041	0.0094
Resources and infrastructure					
Land area (% of site)	21.9	0.0	0.6	0.53	23.0
Water use (% capacity)	50.0	0.09	0.11	0.02	50.2
Wastewater production (% capacity)	22.9	0.0	0.0	0.13	23.0
Power demand (% capacity)	51.5	0.0	0.05	0.03	51.5
Air quality[i]	None	PM_{10}	None	None	PM_{10}
Groundwater quality[j]	19 parameters[k]	Uranium-238	None	None	19 parameters[l]

a Includes impacts of current UF_6 generation and management activities; waste management activities; conversion of uranium ore into UF_6 at the AlliedSignal, Inc., plant in Metropolis, Illinois (NRC 1995); electrical power generation at the Tennessee Valley Authority's Shawnee power plant and at the Joppa Electric Energy, Inc., power plant (DOE 1998b); and environmental restoration activities that have proceeded to a point where their consequences can be defined: Waste Area Groupings 1 and 7 (Solid Waste Management Units C-611, C-746-K, C-740), Grouping 6 (C-400, C-403, and C-400 to C-404 underground transfer line), Grouping 15 (24—C-750, 97—C-601, 139—C-746-A1, 140—C-746-A2, 72—C-200-A, 73—C-710-B), Grouping 17 (36 different concrete rubble piles), Grouping 22 (C-404, C-747-A, C-749), and Grouping 23 (C-340, C-540-A, C-541-A, C-611, C-728, C-747-C) (LMES 1997c).

b The greater of either: (1) impacts from 41 years of continued storage under the No Action Alternative or (2) impacts from 20 years of continued storage under the Action Alternatives.

c Includes impacts related to the preferred alternative for waste management at the Paducah site (DOE 1997a); continuation of conversion of uranium ore into UF_6 at the AlliedSignal, Inc., plant at Metropolis, Illinois (NRC 1995); and treatment of mixed wastes through the Vortec vitrification system (DOE 1998b). They also consider air quality impacts from the Tennessee Valley Authority's Shawnee power plant and from the Joppa Electric Energy, Inc., power plant (DOE 1998b).

d Cumulative impacts equal the sum of the impacts of existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions.

e Assumes 0.0005 LCF/person-rem.

f Based on LMES (1996a), which contains releases for the year 1994. Cumulative impacts assumes all facilities operate simultaneously and are located at the same point.

g Includes both facility and noninvolved workers. Assumes 0.0004 LCF/person-rem.

h The number of truck and rail shipments of radioactive materials. The MEIs (at gate) for truck and rail shipments were assumed to be different.

I Impacts indicate which emissions would result in nonattainment. PM_{10} = particulate matter less than or equal to 10 μm in diameter.

j Impacts of depleted UF_6 management activities, environmental restoration activities, or other future actions indicate whether water quality could be affected in the future.

k Antimony, benzene, cis-1,2-dichloroethene, chromium, 1,2-dichloroethane, 1,1-dichloroethene, ethyl benzene, fluoride, lead, nickel, nitrate, radium-226, radon-222, technetium-99, tetrachloroethene, thallium, trichloroethylene, uranium, and vinyl chloride.

l Only 19 parameters are shown rather than 20 because uranium is included in more than one column (i.e., it is in existing operations as well as continued storage).

Sources: LMES (1996a; 1997c), DOE (1997a; 1998b), and NRC (1995).

During continued storage of depleted UF_6, releases from breached cylinders could result in increased concentrations of uranium in the groundwater. If current cylinder maintenance programs control continued cylinder corrosion, the groundwater analysis indicates that the maximum uranium concentration in groundwater (from cylinder breaches) would be 6 µg/L, considerably below the 20 µg/L guideline level used for comparison (EPA 1996). If no credit is taken for reduced cylinder corrosion rates from painting and maintenance, cylinder breaches occurring at Paducah before the year 2020 could result in groundwater concentrations of uranium exceeding 20 µg/L in the future.

5.8.2.2 Portsmouth Site

Actions planned at the Portsmouth site include the continuation of existing operations, waste management activities, environmental restoration activities, and the depleted UF_6 management activities addressed in this PEIS. Table 5.13 identifies the projected cumulative impacts that could result from future depleted UF_6 management activities and current activities at Portsmouth. As identified in the table, the maximum annual radioactive releases associated with depleted UF_6 management activities would result in a very slight increase in the radiation dose to the off-site population. However, cumulative radioactive releases would still be considerably below the DOE dose limit of 100 mrem/yr to the off-site MEI.

The depleted UF_6 management activities would be unlikely to result in any additional land disturbance at Portsmouth because all activities are expected to occur on currently developed land. On-site infrastructure demands for water, wastewater treatment, and power would increase by at most very small amounts due to depleted UF_6 management activities. Cumulative requirements would remain well within existing capacities.

The Portsmouth site is located in an attainment region where criteria air pollutants do not currently exceed regulatory standards. During construction activities at the site for continued storage or cylinder preparation, pollutant concentrations at the facility boundary would generally not exceed applicable air quality standards or guidelines. If short-term concentrations of fugitive dust emissions (PM_{10}) approached air quality standards during construction, these impacts would be temporary and could be minimized by good engineering and construction practices and standard dust suppression methods.

On the basis of data from 1996 annual groundwater monitoring, 11 pollutants have been found to exceed primary drinking water regulation levels in groundwater at the Portsmouth site: chromium, uranium, chloroform, cis-1,2-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1,-dichloroethene, Freon-113, 1,1,1-trichloroethane, trichloroethylene, and vinyl chloride (LMES 1997d). Elevated levels of technetium-99 have also been detected in groundwater.

TABLE 5.13 Cumulative Impacts of Depleted UF_6 Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at the Portsmouth Site, 1999 through 2039

Impact Category	Impacts of Existing Operations[a]	Maximum Impacts of Depleted UF_6 Management Activities: Continued Storage[b]	Maximum Impacts of Depleted UF_6 Management Activities: Cylinder Preparation	Impacts of Other Reasonably Foreseeable Future Actions[c]	Cumulative Impacts[d]
Off-site population					
Collective dose, 41 years (person-rem)	1.2	0.05	0.001	0.0054	1.3
Number of LCFs[e]	0.001	0.00002	6.0×10^{-7}	2.7×10^{-6}	6.3×10^{-4}
Annual dose to off-site MEI[f] (mrem)	0.066	0.02	4.5×10^{-5}	6.8×10^{-5}	0.069
Worker population					
Collective dose, 41 years (person-rem)	7,000	380	690	14.6	8,085
Number of LCFs[g]	2.80	0.16	0.28	0.0058	3.2
Transportation[h]					
Number of truck shipments, 41 years	10,660	–	13,421	34,090	58,171
Number of rail shipments, 41 years	8,815	–	3,356	13,000	25,171
Annual dose to MEI from truck (mrem)	1.04	–	0.0036	0.055	1.10
Annual dose to MEI from rail (mrem)	0.86	–	0.0025	0.021	0.88
Resources and infrastructure					
Land area (% of site)	21.6	0.0	0.6	0.34	22.5
Water use (% capacity)	36.8	0.07	0.07	0.06	37.0
Wastewater production (% capacity)	81.1	0.0	0.0	0.65	81.8
Power demand (% capacity)	79.2	0.0	0.06	0.11	79.4
Air quality[i]	None	None	None	None	None
Groundwater quality[j]	12 parameters[k]	None	None	None	12 parameters[k]

[a] Includes impacts of current UF_6 generation and management activities, waste management activities, environmental restoration activities that have proceeded to a point where their consequences can be defined (Peter Kiewit landfill, X-611A lime salvage lagoons, X-749/X-120 interim action, X-705A/B soil removal action, sitewide drainage ditches), and the components of the experimental Technology Applications Program applied at the Portsmouth site (X-231B oil biodegradation plot technology demonstration field tests, X-701B in situ chemical oxidation, X-701B surfactant studies, X-623 inorganic photo catalytic membrane treatment study, X-231A soil fracturing demonstrations, X-625 passive groundwater treatment through reactive media, in situ radiological decontamination demonstration in X-326, TechXtract™ surface decontamination process) (Bechtel Jacobs Company LLC 1998b).

[b] The greater of either: (1) impacts from 41 years of continued storage under the No Action Alternative or (2) impacts from 20 years of continued storage under the Action Alternatives.

[c] Includes impacts related to the preferred alternative to waste management at the Portsmouth site (DOE 1997a).

[d] Cumulative impacts equal the sum of the impacts of existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions.

[e] Assumes 0.0005 LCF/person-rem.

[f] Based on LMES (1996b), which contains releases for the year 1994. Cumulative impacts assumes all facilities operate simultaneously and are located at the same point.

[g] Includes both facility and noninvolved workers. Assumes 0.0004 LCF/person-rem.

[h] The number of truck and rail shipments of radioactive materials. The MEIs (at gate) for truck and rail shipments were assumed to be different.

[i] Impacts indicate which emissions would result in nonattainment.

[j] Impacts of depleted UF_6 management activities, environmental restoration activities, or other future actions indicate whether water quality could be affected in the future.

[k] Chloroform, chromium, cis-1,2-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, Freon-113, technetium-99, 1,1,1-trichloroethane, trichloroethylene, uranium, and vinyl chloride.

Sources: LMES (1996b, 1997d), DOE (1997a), and Bechtel Jacobs Company LLC (1998b).

During continued storage of depleted UF_6, releases from breached cylinders could result in increased concentrations of uranium in the groundwater. If current cylinder maintenance programs control continued cylinder corrosion, the groundwater analysis indicates that the maximum uranium concentration in groundwater (from cylinder breaches) would be 5 µg/L, considerably below the guideline level used for comparison, 20 µg/L (EPA 1996). If no credit is taken for reduced cylinder corrosion rates from painting and maintenance, cylinders would have to undergo uncontrolled corrosion until about 2050 before groundwater concentrations of uranium would approach 20 µg/L in the future. The groundwater concentration would not actually reach 20 µg/L until later than the year 2100.

5.8.2.3 Oak Ridge Reservation: K-25 Site

This analysis considers all actions on the Oak Ridge Reservation and is not limited to the K-25 site alone, except where specified. Aside from the continuation of existing operations and depleted UF_6 management activities, reasonably foreseeable future actions at the Oak Ridge Reservation include waste management activities (DOE 1997a), stockpile stewardship and management activities (DOE 1996c), storage and disposition of weapons-usable fissile materials (DOE 1996i), the disposition of highly enriched uranium (DOE 1996a), interim storage of enriched uranium (DOE 1994c), the transfer of nonnuclear functions (DOE 1993), changes in the sanitary sludge land application program (DOE 1996i), proposed reindustrialization of the K-25 site as the East Tennessee Technology Park (DOE 1997b), and environmental restoration activities at the K-25 site (DOE 1997c). Many of these future actions would take place at the other two sites (Y-12 and ORNL) at the Oak Ridge Reservation. However, because of the overlapping region of influence, except for cases where available data preclude a reservationwide view, the cumulative impacts for K-25 generally include the impacts for the Oak Ridge Reservation as a whole.

Table 5.14 identifies the projected cumulative impacts that would result from the two depleted UF_6 management activities that would occur at the K-25 site, existing activities, and planned actions described in the aforementioned EISs. The off-site MEI is specific to K-25. As identified in the table, annual radioactive releases would increase as a result of releases from the depleted UF_6 management activities, depleted UF_6 transport, and other possible actions associated with the Oak Ridge Reservation. However, maximum cumulative radioactive releases would remain below the DOE dose limit of 100 mrem/yr to the off-site MEI.

Depleted UF_6 management activities would affect a maximum of about 7 additional acres (2.8 ha) at K-25, while other actions could affect another 975 acres (390 ha). This area is about 13.9% of the total suitable acreage at K-25. The demand for water, wastewater, and power at the Oak Ridge Reservation would not be greatly affected by depleted UF_6 activities that would occur at K-25. Cumulatively, water, wastewater, and power facilities at the Oak Ridge Reservation would not require major improvements (expansions or upgrades) because projected cumulative future demand is less than existing capacities.

TABLE 5.14 Cumulative Impacts of Depleted UF_6 Activities, Existing Operations, and Other Reasonably Foreseeable Future Actions at the Oak Ridge Reservation, 1999 through 2039

Impact Category	Impacts of Existing Operations[a]	Maximum Impacts of Depleted UF_6 Management Activities: Continued Storage[b]	Maximum Impacts of Depleted UF_6 Management Activities: Cylinder Preparation	Impacts of Other Reasonably Foreseeable Future Actions[c]	Cumulative Impacts[d]
Off-site population					
Collective dose, 41 years (person-rem)	1,763	0.34	0.002	21.4	1,780
Number of LCFs[e]	0.88	0.0004	1.0×10^{-6}	0.011	0.89
Annual dose to off-site MEI[f] (mrem)	9.82	0.46	3.0×10^{-5}	0.62	10.8
Worker population					
Collective dose, 41 years (person-rem)	2,788	200	480	3,400	6,880
Number of LCFs[g]	1.12	0.08	0.19	1.36	2.75
Transportation[h]					
Number of truck shipments, 41 years	42,640	–	4,732	70,834	118,206
Number of rail shipments, 41 years	328	–	1,183	26,000	27,511
Annual dose to MEI from truck (mrem)	4.2	–	0.0013	0.20	4.4
Annual dose to MEI from rail (mrem)	0.032	–	0.0009	0.068	0.10
Resources and infrastructure					
Land area (% of site)[i]	26.0	0.14	0.4	13.9	40.5
Water use (% capacity)	45.5	0.01	0.05	0.5	46.1
Wastewater production (% capacity)[j]	69.6	0.0	0.0	17.2	86.8
Power demand (% capacity)[j]	10.9	0.0	0.09	21.8	32.8
Air quality[k]	None	PM_{10}, HF	None	None	PM_{10}, HF
Groundwater quality[l]	24 parameters[m]	Uranium-238	None	6 parameters[n]	27 parameters[o]

[a] Includes impacts of current UF_6 management activities, waste management activities, and environmental restoration activities (at K-25) that have proceeded to a point where their consequences can be defined: Watershed I, Watershed II, Watershed III, Watershed IV, Watershed V, Watershed VI, and non-Watershed Areas (individual projects listed in DOE 1997c).

[b] The greater of either: (1) impacts from 41 years of continued storage under the No Action Alternative or (2) impacts from 20 years of continued storage under the Action Alternatives.

[c] These include impacts from EISs related to (1) stockpile stewardship and management (DOE 1996c), (2) storage and disposition of weapons-usable fissile materials (DOE 1996d), (3) disposition of surplus highly enriched uranium (DOE 1996a), (4) transfer of nonnuclear functions (DOE 1993), (5) waste management (DOE 1997a), (6) proposed changes in the sanitary sludge land application program (DOE 1996i), and (7) potential reindustrialization of the K-25 site (DOE 1997b). Impacts of reasonably foreseeable future actions do not include the potential environmental impacts of constructing and operating a proposed CERCLA waste management facility or the potential impacts of constructing and operating a barge facility, both of which will be estimated in the future at a time closer to the development of those two facilities (see DOE 1997b).

[d] Cumulative impacts equal the sum of the impacts of existing operations, depleted UF_6 management options, and other reasonably foreseeable future actions.

[e] Assumes 0.0005 LCF/person-rem.

[f] MEI at K-25. Based on LMES (1995a), which contains releases for the year 1994. Cumulative impacts assumes all facilities operate simultaneously and are located at the same point.

[g] Includes both facility and noninvolved workers. Assumes 0.0004 LCF/person-rem.

[h] The number of truck and rail shipments of radioactive materials. The MEIs (at gate) for truck and rail shipments were assumed to be different.

[i] Land area impacts are determined on the basis of the K-25 site area of 4,845 acres (1,961 ha) (including undeveloped sections) rather than the total Oak Ridge Reservation area of 34,516 acres (13,974 ha), since Oak Ridge Reservation consists of three main areas of activity separated by large tracts of a National Environmental Research Park that will largely remain undeveloped.

[j] Considers K-25 only.

[k] Impacts indicate which emissions would result in nonattainment. PM_{10} = particulate matter less than or equal to 10 µm in diameter.

[l] Existing groundwater quality impacts are for the K-25 site only. Impacts of depleted UF_6 management activities, environmental restoration activities, or other future actions indicate whether water quality could be affected.

[m] Antimony, arsenic, barium, benzene, cadmium, carbon tetrachloride, chloroform, chromium, 1,1-dichloroethene, 1,2-dichloroethene, fluoride, lead, methylene chloride, nickel, technetium-99, tetrachloroethene, thallium, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, 1,1,2-trichloro-1,2,2-trifluoroethane, uranium, and vinyl chloride.

[n] 1,2-Dichloroethane, methylene chloride, plutonium-239, plutonium-240, technetium-99, and uranium-238.

[o] Only 27 parameters would be exceeded instead of 31 because methylene chloride, technetium-99, and uranium could be exceeded under existing operations, continued storage, and as a result of other future actions (i.e., they are included in more than one column).

Sources: LMES (1996c, 1996d); DOE (1997a).

The Oak Ridge Reservation is located in an attainment region where criteria air pollutants do not currently exceed regulatory standards. For construction activities at the K-25 site for continued storage or cylinder preparation, pollutant concentrations at the facility boundary would generally not exceed applicable air quality standards or guidelines. If short-term concentrations of fugitive dust emissions (PM_{10}) approached air quality standards during construction, these impacts would be temporary and could be minimized by good engineering and construction practices and standard dust suppression methods.

If current cylinder maintenance programs control continued cylinder corrosion, the air analysis indicates that the maximum HF concentration at the site boundary could reach a maximum of 23% of the standard. However, if no credit is taken for control of corrosion, the HF concentration could approach the primary standard concentration of 29 $\mu g/m^3$ (24-hour average) around the year 2020.

On the basis of data from 1994 and 1995 annual groundwater monitoring, 23 pollutants have been found to exceed primary drinking water regulation levels in groundwater at the K-25 site: antimony, arsenic, barium, cadmium, chromium, fluoride, lead, nickel, thallium, uranium (as estimated from gross alpha levels), benzene, carbon tetrachloride, chloroform, 1,1,-dichloroethene, 1,2-dichloroethene, methylene chloride, tetrachloroethene, toluene, 1,1,2-trichloro-1,2,2-trifluoroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, and vinyl chloride (LMES 1995a; 1996d). Gross beta levels (possibly indicative of technetium-99) also exceeded the standard. Another six pollutants could affect groundwater quality as a result of reasonably foreseeable future actions; these are 1,2-dichloroethane, methylene chloride, plutonium-239, plutonium-240, technetium-99, and uranium-238.

During continued storage of depleted UF_6, releases from breached cylinders could result in increased concentrations of uranium in the groundwater. If current cylinder maintenance programs control continued cylinder corrosion, the groundwater analysis indicates that the maximum uranium concentration in groundwater (from cylinder breaches) would be 7 µg/L, considerably below the 20 µg/L guideline level used for comparison (EPA 1996). If no credit is taken for reduced cylinder corrosion rates from painting and maintenance, cylinders would have to undergo uncontrolled corrosion until about 2025 before groundwater concentrations of uranium would approach 20 µg/L in the future. The groundwater concentration would not actually reach 20 µg/L until later than the year 2100.

5.8.3 Impacts of Facility Colocation

The cumulative impact analyses presented in Section 5.8.2 were based on the assumption that long-term storage, conversion, and disposal facilities would not be colocated with storage and cylinder preparation facilities and therefore would not be placed at any of the three current cylinder storage sites. However, colocation of facilities at these sites is a possibility for certain alternatives. Table 5.15 lists the most probable colocation scenarios for the alternatives considered in this PEIS,

TABLE 5.15 Potential Colocation of Facilities and the Alternatives Affected

Facilities	Alternatives
Continued storage + Conversion	Long-term storage as oxide Disposal Use as oxide and metal Preferred alternative
Continued storage + Conversion + Long-term storage as oxide	Long-term storage as oxide Preferred alternative
Continued storage + Long-term storage as UF_6	Long-term storage as UF_6

scenarios that involve the addition of one or more facilities to the sites where current storage already is under way. A detailed analysis of potential impacts resulting from colocation would be the subject of site-specific Phase II NEPA reviews. One positive result of colocation would be the elimination of impacts associated with transporting material between sites that have been colocated. In this PEIS, effects associated with shipping depleted UF_6, either in original form or a converted form, can involve site-specific and non-site-specific issues. The former concerns activities associated with the preparation of material for shipping, most notably impacts considered under cylinder preparation activities that occur at the current storage site prior to transporting depleted UF_6 elsewhere. Non-site-specific issues, in contrast, primarily concern the shipment of material (depleted UF_6 in either original or a converted form) from one site to another. The reduction of impacts associated with the actual transport of material can yield advantages since these impacts are among the largest of the impacts associated with particular alternatives.

5.9 ISSUES RELATED TO POTENTIAL LIFE-CYCLE IMPACTS

All of the PEIS alternatives, except for disposal as uranium oxide, would require the continued management of depleted uranium beyond 2039, the time period addressed in detail in the PEIS. With the exception of potential long-term groundwater impacts from continued cylinder storage and disposal, the potential environmental impacts of management activities beyond 2039 were not evaluated in the PEIS because the specific actions that would take place are considered highly uncertain and speculative and are not ready for decision at this time. However, this section discusses issues related to the potential life-cycle impacts associated with depleted uranium management.

If a long-term storage alternative (no action, long-term storage as UF_6, or long-term storage as oxide) is selected in the Record of Decision for the PEIS, several actions could occur beyond

2039: the depleted uranium could continue to be stored, it could be used or disposed of, or it could be converted to another chemical form and used or disposed of.

The continued storage of depleted uranium beyond 2039 may require the replacement or refurbishment of storage containers and facilities as their design lifetimes are exceeded. The extent of such activities would depend heavily on the environmental storage conditions, maintenance performed, performance and condition of the containers and facilities over time, and applicable regulatory requirements at that time. With proper monitoring and maintenance and with replacement and refurbishment as needed, storage could, in theory, continue indefinitely with minimal impacts to workers and the environment.

If a decision is made in the future to use or dispose of the depleted uranium in storage, it is possible that conversion to a different chemical form may be required. For example, if the depleted uranium is stored as UF_6, conversion to uranium oxide or uranium metal may be necessary before use. Similarly, disposal may also require conversion to a suitable chemical form, such as uranium oxide. Such activities would depend on the nature of the uses identified in the future and the applicable regulatory requirements at the time of disposal.

If a use alternative is implemented (use as oxide, use as metal, or a combination such as in the preferred alternative), depleted uranium might also require management after use. After use, products containing depleted uranium could potentially be stored, reused, recycled for other uses, or they could be treated (e.g., converted to another chemical form) and disposed of as LLW. The ultimate fate of the depleted uranium after use would depend in part on market demand, economic considerations, and the applicable regulatory requirements at that time.

If the decision is made to dispose of depleted uranium products after use, treatment may be necessary. If the depleted uranium is used in the form of uranium oxide, treatment requirements would likely be minimal (e.g., volume reduction and packaging as needed) because uranium oxide is the current preferred chemical form for disposal. More extensive treatment may be required if the depleted uranium is used in the form of uranium metal. Current regulatory criteria restrict the chemical form for disposal. Reactive waste forms, such as depleted uranium metal, are specifically excluded from disposal at the two DOE LLW disposal sites at the Nevada Test Site and the Hanford Site. Current waste acceptance criteria would likely need to be relaxed before disposal of bulk quantities of uranium metal could occur. Conversely, uranium metal could be converted to uranium oxide before disposal, and a conversion facility would likely be required.

Some uses might also result indirectly in the permanent disposal of the material. For example, casks containing depleted uranium could be used as part of a disposal package for spent nuclear fuel or HLW in a geologic repository. Pursuant to the Nuclear Waste Policy Act, DOE is currently characterizing the Yucca Mountain site in Nevada as a potential repository for spent nuclear fuel and HLW. Only casks that met the acceptance criteria of such a repository would be used for disposal. In addition, future uses may also consume the depleted uranium as fuel in advanced nuclear reactors, with the resulting spent nuclear fuel disposed of accordingly.

5.10 MITIGATION

The impacts of the alternatives presented in this chapter are primarily the maximum impacts expected for the range of options included within each alternative. Factors such as flexibility in siting and collocation, technology selection, and facility design and construction could be used to reduce impacts from these maximum levels. This section identifies what impacts could be mitigated to reduce adverse impacts. The assessment of specific technologies, siting considerations, and facility design and construction are issues that will be addressed in Phase II NEPA reviews and future decisions related to siting, technology selection, or facility construction and operations. However, based on the analyses conducted for this PEIS, the following recommendations can be made:

- Temporary impacts on air quality from dust emissions during construction of any new facility should be controlled by the best available practice to avoid temporary exceedances of the PM_{10} standard.

- Eventual impacts on air and groundwater at the current storage sites should be avoided by cylinder inspection, cylinder maintenance (such as painting), and prompt cleanup of any releases from any breached depleted UF_6 cylinders. Additionally, collection and sampling of runoff from cylinder yards should allow detection of contaminant releases to avoid releases to surface water or groundwater.

- Future impacts on groundwater from failure of a disposal facility could be minimized by selection of a site in a dry environmental setting.

- If a new mine were to be used for long-term storage or disposal, tailings from the excavation would be disposed of at the surface. These tailings should be graded to be compatible with existing topography and surrounding land uses and revegetated with native species or species compatible with the surrounding environment.

Although the probability of transportation accidents involving hazardous chemicals such as HF and ammonia is very low, the consequences could be severe. The colocation of facilities could minimize the amount of transportation required and could reduce this risk. For this PEIS, the assessment of transportation accidents involving anhydrous HF assumed conservative conditions. Currently, a number of industry practices are commonly employed to minimize the potential for large HF releases, as discussed below.

Anhydrous HF is usually shipped in 100-ton, 23,000-gal (91-metric ton, 87,000-L) shell, full, noncoiled, noninsulated tank cars. Most HF railcars today meet the DOT classification 112S500W, which represents the current state-of-the-art. To minimize the potential for accidental releases, these railcars have head shields and employ shelf couplers, which assist in avoiding punctures during an accident. The use of these improved state-of-the-art tank cars has led to an improved safety record with respect to HF accidents over the last several years. The HF transportation accident rate has steadily decreased since 1985. Industry recommendations for the new tank car guideline appear in *Recommended Practices for the Hydrogen Fluoride Industry* (Hydrogen Fluoride Industry Practices Institute 1995b).

Accidents involving anhydrous HF and ammonia at a conversion facility were estimated to have potentially serious consequences. A wide variety of good engineering and mitigative practices are available that affect siting, design, and accident mitigation for HF or ammonia storage tanks, such as might be present at a conversion facility. Many are summarized in *Guideline for the Bulk Storage of Anhydrous Hydrogen Fluoride* (Hydrogen Fluoride Industry Practices Institute 1995a). There is an advanced set of accident prevention and mitigative measures that are recommended by industry for HF storage tanks, including storage tank siting principles (e.g., evaluating seismic and high wind conditions or drainage conditions), design recommendations, and tank appurtenances, as well as spill detection, containment, and mitigation. Measures to mitigate the consequences of an accident include anhydrous HF detection systems, spill containment systems such as dikes, remote storage tank isolation valves, water spray systems, and rapid acid deinventory systems (removing acid rapidly from a leaking vessel). Details on these mitigative strategies are also provided in the Hydrogen Fluoride Industry Practices Institute (1995a) guidelines.

5.11 UNAVOIDABLE ADVERSE IMPACTS

Unavoidable adverse impacts are those impacts that cannot be mitigated by strategy selection and future considerations of technology selection, siting, and facility construction. Some impacts would be unavoidable, no matter which strategy were selected.

The depleted UF_6 cylinders currently in storage would require continued monitoring and maintenance for all alternatives. These activities would result in exposures of workers to low levels of radiation in the vicinity of the cylinders. The radiation exposure of workers can be minimized, but some level of exposure is unavoidable. The radiation doses to workers were estimated to be well within public health standards for all alternatives. Radiation exposures of workers would be monitored at each facility and would be kept as low as reasonably achievable. Cylinder monitoring and maintenance activities would also produce emissions of air pollutants, such as vehicle exhaust and dust (PM_{10}), and produce small amounts of sanitary waste and LLW. Concentrations of air emissions during operations were estimated to be within applicable standards and guidelines, and waste generation would not appreciably affect waste management operations.

All alternatives would involve a potential for accidental on-the-job injuries and fatalities among workers, unrelated to radiation or chemical exposures. These impacts are a consequence of unanticipated events in the work environment, typical of all work places. Based on statistics in similar industries, from 1 to 4 accidental fatalities and up to several thousand worker injuries were estimated for the PEIS alternatives. The chance of fatalities and injuries occurring would be minimized by conducting all work activities in as safe a manner as possible, in accordance with occupational health and safety rules and regulations. However, the chance of these type of impacts cannot be completely avoided.

All alternatives other than the no action alternative might require the construction of new facilities, for purposes of cylinder preparation, conversion, long-term storage, or disposal. Up to several hundred acres could be required for some alternatives. Construction of new facilities could result in losses of terrestrial and aquatic habitats. Dispersal of wildlife and temporary elimination of habitats would result from land-clearing and construction activities involving movement of construction personnel and equipment. The construction of new facilities could cause both short-term and long-term disturbances of previously undisturbed biological habitats. Although some destruction would be inevitable during and after construction, these losses would be minimized by careful site selection and thorough environmental reviews at a site-specific level.

5.12 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The major irreversible and irretrievable commitments of natural and man-made resources related to the alternative management strategies for depleted UF_6 that can be identified at this programmatic level of analysis are discussed in Sections 5.12.1 through 5.12.3. A commitment of resources is irreversible when its primary or secondary impacts limit the future options for a resource. An irretrievable commitment refers to the use or consumption of resources neither renewable nor recoverable for later use by future generations.

The programmatic decisions resulting from this PEIS would commit resources required for implementing the selected alternative. Three major resource categories would be committed irreversibly or irretrievably under the alternative management strategies considered in this PEIS: land, materials, and energy.

5.12.1 Land

Land that is currently occupied by or ultimately selected for UF_6 cylinder storage or potential conversion, manufacture, or long-term storage facilities could ultimately be returned to open space if the yards, buildings, roads, and other structures were removed, areas cleaned up, and the land revegetated. Future use of these tracts of land, although beyond the scope of this PEIS, could include restoring those areas for unrestricted use. Therefore, commitment of this land is not necessarily irreversible. However, land set aside for radioactive, hazardous, and chemical waste disposal represents an irretrievable commitment because wastes in belowground disposal areas could not be completely removed, the land could not be restored to its original condition or to minimum cleanup standards, nor could the site be feasibly used for any other purposes following closure of the disposal facility. The disposal facilities evaluated in this PEIS could require up to 470 acres (188 ha). This land would be permanently unusable because the ground would no longer be suitable for intrusive activities, such as mining or utilities. The surface area appearance and biological habitat potentially lost during construction and operation of the disposal facilities could, however, be restored to a large extent.

5.12.2 Materials

The irreversible and irretrievable commitment of material resources for the various PEIS alternatives includes construction materials that could not be recovered or recycled, materials rendered radioactive that could not be decontaminated, and materials consumed or reduced to unrecoverable forms of waste. Where construction was necessary, materials required would include wood, concrete, sand, gravel, steel, aluminum, and other metals. At this time, no unusual construction material requirements have been identified. The construction resources, except for those that could be recovered and recycled with current technology, would be irretrievably lost. None of the identified construction resources is in short supply, and all should be readily available. Consumption of operating supplies such as paper, miscellaneous chemicals such as sodium hydroxide, and gases such as argon and nitrogen, although irretrievable, would not constitute a permanent drain on local sources or involve any material in critically short supply in the United States as a whole. Strategic and critical materials (e.g., Monel and Inconel) would not be required in quantities that would seriously reduce the national or world supply.

Any decision to dispose of depleted uranium without prior application as a use option would represent an irretrievable commitment of a potential material resource. Disposal is by definition irreversible, and the depleted uranium would be lost forever as a material resource.

5.12.3 Energy

The irretrievable commitment of energy resources during construction and operations of the various facilities considered by the alternatives would include the consumption of fossil fuels used to generate heat and electricity for the facilities. Energy would also be expended in the form of diesel fuel, gasoline, and oil for construction equipment and transportation vehicles. Under the long-term storage as UF_6, long-term storage as oxide, and disposal alternatives, options involving mine storage or disposal would require large quantities of electrical energy during construction (up to 1,100 MW-yr). The availability of this electricity would depend on site location.

Any decision to dispose of depleted uranium would represent an irretrievable commitment of a potential energy resource. Depleted uranium is a potential fuel for future nuclear breeder reactors. Disposal is by definition irreversible, and the depleted uranium would be lost forever as a potential energy resource.

5.13 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

For this PEIS, short term was considered the period of construction activities for the alternative management strategies — the time when most short-term (or temporary) environmental impacts would occur. Most alternatives would require the use of additional land. Such use would remove this land from other beneficial uses until at least the year 2040 because of the presence of long-term hazards. Disposal of solid nonhazardous waste generated from new facility construction and operations would require additional land at a sanitary landfill site, which would be unavailable for other uses in the long term. Any LLW generated by the various alternatives would involve the commitment of associated land, transportation, processing facilities for waste management, and disposal resources.

For those alternatives involving the construction and operation of new facilities, the associated construction activities would result in both short-term and long-term losses of terrestrial and aquatic habitats from natural productivity. Dispersal of wildlife and temporary elimination of habitats would result from land clearing and construction activities involving movement and staging of construction personnel and equipment. The building of new facilities could cause long-term disturbances of previously undisturbed biological habitats, potentially causing long-term reductions in the biological activity of an area. Although some habitat loss would be inevitable during and after construction, these losses would be minimized by careful site selection and by thorough environmental reviews at a site-specific level. Short-term impacts would be reduced and mitigated as necessary. After closure of the new facilities (beyond 40 years), they would be decommissioned and could be reused, recycled, or remediated.

5.14 POLLUTION PREVENTION AND WASTE MINIMIZATION

Implementation of any of the PEIS alternatives would be conducted in accordance with all applicable pollution prevention and waste minimization guidelines. Pollution prevention utilizes source reduction techniques in order to reduce risk to public health, safety, welfare, and the environment, and environmentally-acceptable recycling to achieve these same goals. The *Pollution Prevention Act* of 1990 (42 USC 11001-11050) established a national policy that pollution should be prevented or reduced at the source, whenever feasible. Under the Act, pollution that cannot be prevented should be recycled in an environmentally safe manner. Disposal or other releases into the environment should only be employed as a last resort. Executive Order 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements" (U.S. President 1993), and DOE Order 5400.1, "General Environmental Protection Program," implement the provisions of the *Pollution Prevention Act* of 1990. DOE has established goals for reducing the generation and release of toxic chemicals, all types of waste, and pollutants. These waste-reduction goals (to be achieved by December 31, 1999) use calendar year 1993 as the baseline year for measuring progress. *The 1996 Pollution Prevention Program Plan* (DOE 1996f) was issued by the Secretary of Energy on May 3, 1996, to serve as the principal crosscutting guidance to DOE Headquarters, DOE Operations Offices, the national laboratories, and contractors to fully implement pollution prevention programs within the DOE complex that would reduce DOE's routine generation of radioactive, mixed, and hazardous wastes, and total releases, and off-site transfers of toxic chemicals. Pollution prevention measures could include source reduction, recycling, treatment, and disposal. The emphasis is on source reduction and recycling to prevent the creation of wastes, i.e., waste minimization.

Waste minimization is the reduction, to the extent feasible, of the generation of radioactive and hazardous waste. Source reduction and waste minimization techniques include good operating practices, technology modifications, input material changes, and product changes. An example of facilitating waste minimization is to substitute nonhazardous materials, where possible, for those materials that contribute to the generation of hazardous or mixed waste.

Many of the facilities considered by the PEIS alternatives are still in the conceptual stages of the engineering and design process. Consideration of opportunities to reduce waste generation at the source, as well as for material recycle and reuse, will be incorporated to the extent possible into the engineering and design process for the selected alternative. Examples of pollution prevention and waste minimization concepts that have been incorporated into the PEIS alternatives include the following:

- A cylinder treatment facility (including removal of residual radioactive contamination [i.e., "heels"] from the cylinders) option was included to allow potential final disposition of empty UF_6 cylinders (after removal of the depleted UF_6 contained within them) to become part of the scrap metal inventory at the gaseous diffusion plant sites and to possibly avoid disposal of the empty UF_6 cylinders as LLW.

- The MgF_2 by-product from conversion of depleted UF_6 into uranium metal would be leached with nitric acid to reduce its level of uranium contamination, which might allow disposal of the MgF_2 in a sanitary landfill.

- Wastes such as paper, aluminum, and other items generated during facility operations were assumed to be collected for pickup by recycling organizations and not disposed of as sanitary waste.

Pollution prevention and waste minimization would be major factors in determining the final design of any facility constructed as part of the decision of a selected PEIS alternative. Specific pollution prevention and waste minimization considerations will be analyzed as part of the Phase II studies and NEPA reviews following the Record of Decision for the PEIS.